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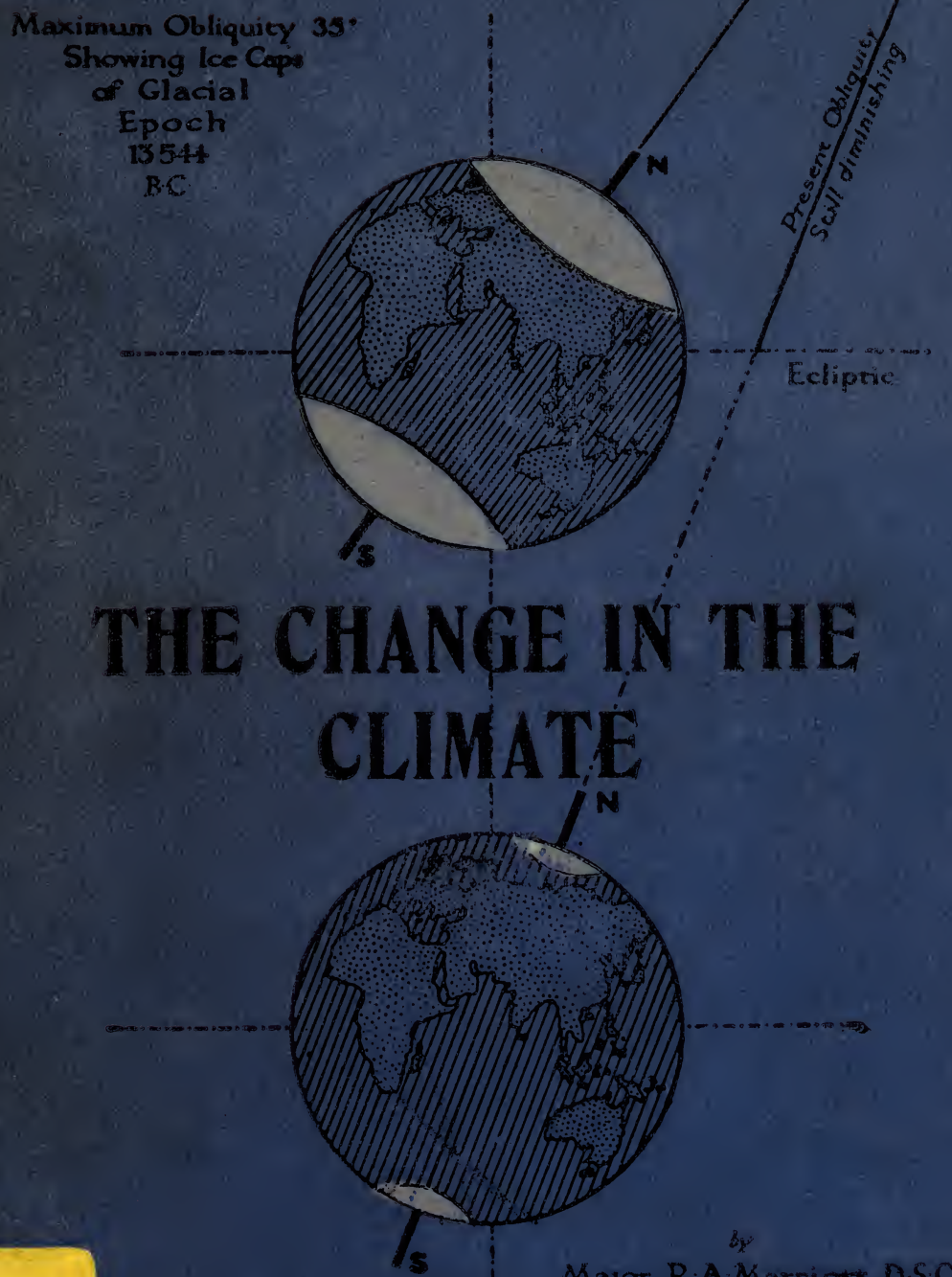
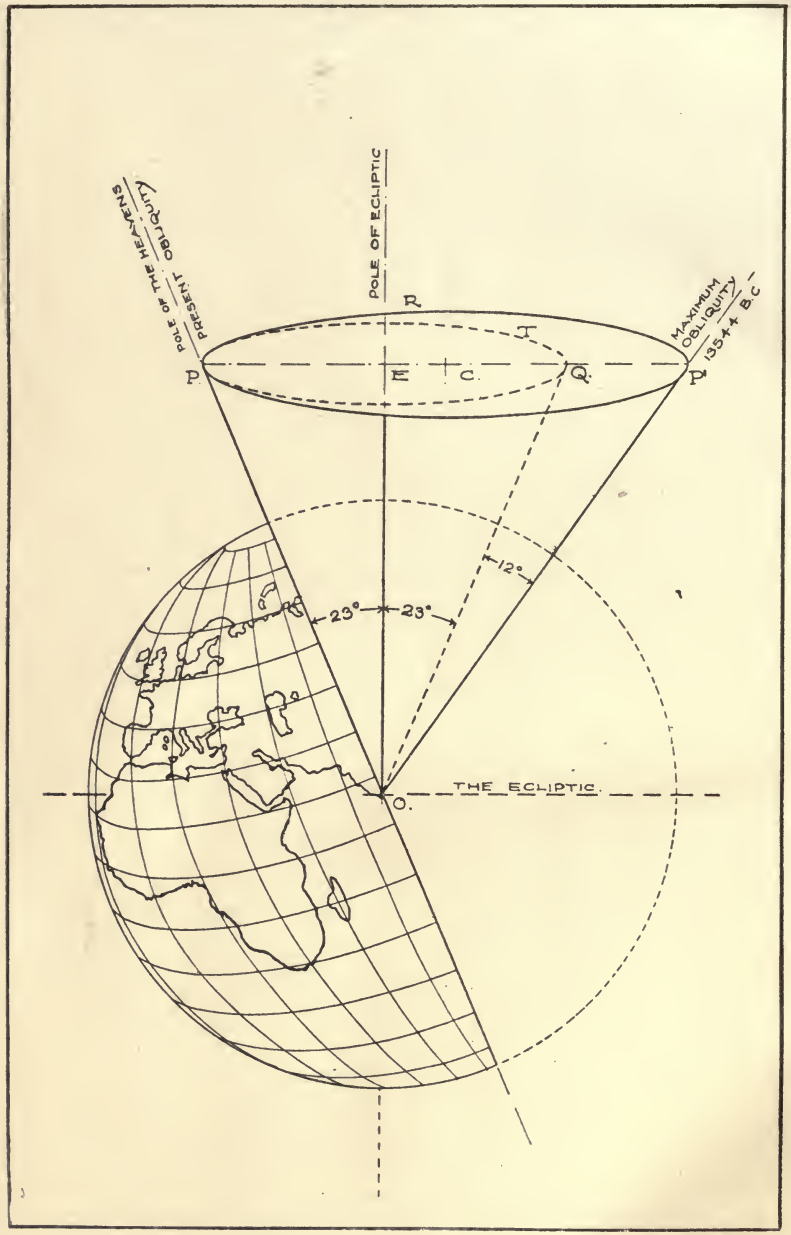


THE CHANGE IN THE CLIMATE

by
Major R.A. Marriott D.S.O.
Late Royal Marine Artillery.

YC 10726

SHOWING THE SLOW CONICAL MOTION OF THE AXIS OF THE EARTH, WHICH CAUSES THE PRECESSION OF THE EQUINOXES.



The dotted circle is supposed to be the path of the pole of the heavens, and to be completed in 25,868 years. The outer circle, however, is the true path, and is completed in 31,682 years (31,756 according to de Horsey). Obliquity of Ecliptic at the maximum 35° 25′ 47″.

THE

CHANGE IN THE CLIMATE

AND

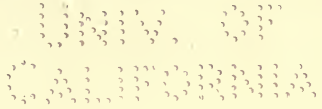
ITS CAUSE

GIVING THE DATE OF THE LAST ICE AGE

BASED ON A RECENT ASTRONOMICAL DISCOVERY

AND

GEOLOGICAL RESEARCH



BY

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THE CHANGE IN THE CLIMATE AND ITS CAUSE.

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PREFACE.

In this book the reasoning has been as far as possible kept free from technicalities. The explanation of the controversial points will, it is hoped, be sufficiently clear to enable the unprofessional reader to follow any further developments with enlightened interest.

The question is, perhaps, of more importance than can now be appreciated, and a careful reading of *all* the arguments is certainly to be recommended. If, however, the broad outlines of the theory relating to the change of climate and the glacial periods are all that is sought for, it is advisable to read mainly the Introduction and Part III.

The discussion of the Invariable Plane argument has so important a bearing on the new aspect of affairs here represented that the suspension of the operation of this factor completely clears the field for the deductions drawn concerning the past and present changes of climate. The cause of these can now be outlined with some certainty, in that the date of the last glaciation, as calculated in the "Views of American Geologists," page 69, is practically proved.

The importance of this discovery to Astronomy will be understood from a perusal of the Comparative Summary, p. 17, and the new time-unit in geological history will henceforth serve as a base-line for a survey of the glacial periods, which it has hitherto been impossible to map out.

It must not be rashly inferred that we shall shortly see a further notable change of climate, or that we shall be free from occasional cold spells of comparative intensity, as it has been a peculiar feature that, with our own warmer winters, more southern lands have of late years experienced unusual snaps of low temperature.

With the new investigations now being made in the upper strata of the atmosphere, meteorologists will perhaps be able to explain why these "flying columns" from the polar regions occasionally invade such southern climes.

R. A. MARRIOTT.

LEWES,
January, 1914.

INTRODUCTION.

In spite of the recent extension of research and of discoveries which bear on geology and the history of man, it is strange that, though constantly making use of the term "pre-glacial," we are in entire ignorance of even an approximate estimate as to when the Glacial Period really occurred.

It follows that in thus sailing without a chronometer Science cannot fix her position, and is obliged to allow great freedom of speculation, and to give equal weight to very diverse opinions on the subject, thus creating a confusion of tongues very detrimental to progress.

We have, however, reached a critical point. The question can no longer remain in its present condition, for after many years of theory, we are now confronted with facts. The assertion that winters are getting warmer is no longer debateable, nor is there any doubt that the ice-fringes at both Poles are being rapidly reduced. This dwindling of the circumpolar ice is of the greatest significance, as it contradicts one assertion of astronomers in a most direct manner.

Three conflicting views are here in dispute—those held by traditional astronomy, those expressed generally by geologists, and those held by Drayson. The conclusions of Drayson, which he first put forward so long ago as 1859, are absolutely in accord with the deductions of many geologists of this generation. Drayson was misunderstood, ridiculed, and forgotten; but now, fifty years afterwards, American and Swedish geologists express their conviction that the change of climate, occasioned by the thawing of the accumulations of the last glacial period, can be fixed within certain date-limits. These, though arrived at on wholly different grounds, tally closely with the date given by Drayson.

It would seem that the next move on the part of these geologists would be the obvious one of acclaiming Drayson as the Newton of the glacial epochs; but, strange to say, though these geologists contemptuously put astronomy to one side as of no use to them, they must needs look askance at Drayson because, forsooth, he carries no credentials from astronomical authorities.

Perhaps the most surprising feature in the development of this question is that orthodox astronomy has placed itself, by its own state-

ment, in an untenable position. The whole astronomical argument establishing a cause and date for the last ice-age in the northern hemisphere will be seen to be founded on an assumption which is contradicted by fact.

No significance so far has been attached by geologists to the fact that the glaciers of Switzerland have been retreating of late, because it was known that they were subject to periodic fluctuations, but they cannot now disregard a retrogression which has been the rule for sixty years. In addition to the result of recent enquiry showing a persistent retreat in sixty-two out of a total of sixty-five glaciers, there is the investigation by M. Vallot of the Mer de Glace, by which he shows that the "ablation," *i.e.*, loss in vertical section since 1850 has been one-eighth of the whole since the passing of the glacial epoch.*

This has led him to doubt the facts generally believed regarding the last great glacier advance of that period, but in reality it serves to show what a rapid change is now in progress.

This is shown all over the world. For instance a source of supply of ice for export in Norway gave out some six years ago, and the industry has been abandoned. Again, the Muir Glacier in Alaska has withdrawn from an inlet which at the beginning of the last century it filled to a depth of from 2,000 to 4,000 feet and from one to five miles in width. With a similar process affecting the whole arctic and antarctic fringe, it is not unreasonable to conjecture that further changes to greater mildness are in store for posterity.

As a preliminary outline of the dispute between Drayson and astronomers, a simple figure is given in the frontispiece in which two circles are viewed in perspective. The dotted circle PTQ marks the curve, which, according to astronomers, is traced by the "pole of the heavens" (the Earth's axis produced), and which will be seen to be always at an angle of 23° from E, the pole of the ecliptic. The larger circle PRP′ is the true path of the pole of the heavens, according to Drayson; and the angular distance 23° of P from E represents the present obliquity of the ecliptic; but as Drayson's circle is centred on C, six degrees from E, when P was at P′, some 15,000 years ago, the obliquity P′E was measured by 35°.

This greater obliquity was the cause of the last ice-age. The movement and its relation to the precession of the equinoxes is fully explained in Part II., page 41.

It may be thought self evident that the greater obliquity tends to cause a glacial period, but no less an authority than Croll, amongst others, has disputed it. It is in reality elementary, but as it is fundamental to the whole question, the logic of it must be here explained.

It stands to reason that if there was *no* obliquity there would be no distinction between winter and summer anywhere, and that if a slight

* From Quarterly Journal Geological Society, Vol. XXXII., September, 1908.

obliquity were then induced, the difference between the seasons would begin to be marked, and words for winter and summer would have to be coined. *A fortiori* the greater the obliquity the greater the contrast between winter and summer, *i.e.*, the winters would become increasingly colder, and the summers increasingly hotter.

The following story taken from Drayson's *Motion of the Fixed Stars* shows the intuition of a child of nature as compared with the dogmatic teaching of the armchair expert.

> " Some years ago when standing on the banks of a lake in " Nova Scotia (a locality well suited to the study of the glacial " period), I observed that the hard rocky shore was cut and marked " by the glaciers and icebergs of the boulder period. In various " inland localities were enormous boulders, which had been carried " many miles from the parent rocks and deposited on what is now " a vast forest. My only companion was Paul, a Micmac Indian. " Pointing to the boulders and rocks, I said, ' Paul, how do you " ' account for all this ? '
>
> " Paul without hesitation replied :
>
> " ' Long time ago more winter in winter, more summer in " summer. More winter make more snow, more icebergs ; more " summer melt snow quicker ; float icebergs more than now. " That what I think.' "

Precisely !

The above condition of 35° of obliquity would thus bring the Arctic circle down to a latitude of 55° in each hemisphere. It is precisely the regions round this latitude which are prolific of signs of the past ice action and glacial disturbance, and this book is an elaboration of the salient facts that some 15,000 years ago Durham was within the Arctic circle ; that the precession of the equinoxes entails great changes of climate ; and that such changes follow each other in a cycle of 31,680 years.

The form of compilation in which it is presented is somewhat unusual, but with the conviction that the Rosetta Stone for deciphering the rock-signs of the glacial period will be found in the writings of General Drayson, and that the stages in the controversy will be of historical interest to science, the writer has left it in the form of three parts in the order of their publication.

Part I. shows that our greater knowledge of the conditions prevailing in the Antarctic circle is all in favour of the formerly rejected theory of Drayson, while it is inimical to the accepted views of astronomy, and that the writer was enabled by the new data to accurately determine the present obliquity of the ecliptic, though to obtain this by observation employs continuously a staff of skilled computers at Greenwich. The explanation given of the probability of rapid change owing to the critical melting point and properties of ice is also an important argument.

This publication did not meet with the acceptance that was anticipated from this and other really cogent proofs that were put forward, though an eminent geologist, Professor Wright of the United States, recognised their extreme importance ; but, by a happy chance, another convinced disciple of Drayson published, at the same time, a book containing the actual working out of stellar problems from Drayson's *data*, furnishing all the minuter details and showing fertile results, thus clinching the proofs from an independent and scientific source. The chart of the curve of obliquity, page 18, for the 30,000 odd years of the cycle is taken from this work by Admiral Sir Algernon de Horsey, entitled *Draysonia* (Longmans).

With the encouragement of this work in support of the theory, Part II. was issued, and the opportunity seized to make more clear the history of the position of astronomers as regards this question.

Equally important for the vindication of Drayson, but from the practical side, was the accumulated evidence of American geologists, which will be hereafter dealt with, together with the opening up of new fields and methods of research in Sweden, under the guidance of Baron de Geer, which furnish a welcome reinforcement of the main argument. It is now established by conclusive evidence that the floor of Stockholm was under an ice-covering not more than 15,000 years ago.

Not least among the gathering circumstantial evidences of a recent ice period, is the discovery by Dr. Allen Sturge in Suffolk of many neolithic flint implements, striated and scratched by being ground under the millstones of invading glaciers. To those cognisant of the properties of flint, the evidence of ice-action appears very strong,* and such etchings constitute a sign-language inscribed by nature on the work of man, serving to show that glaciers had invaded the settlements of a people, who by "culture" methods of reckoning we must regard as of recent-neolithic date.

It is curious that some of the leading English geologists are at present inclined to put the date of glaciation further back than did even the last generation, and this in spite of the researches in America and Sweden. There is, however, a phenomenon in the geology of the British Isles which has been universally noted, but without any attempt at a general explanation, which furnishes an argument favouring the recent date of the glacial period. This is the occurrence of submerged forests all round the coasts of England between low-water mark and the five-fathom line. Everywhere it is of the same character and at about the same horizon.

Diodorus Siculus, the historian, who wrote about the Christian era, speaks of Ictis, which, from the description of its position regarding the tin trade, and its character as alternately an island and a peninsula, corresponds to St. Michael's Mount in Cornwall. This

* As is natural with such revolutionary ideas, these conclusions are running the gauntlet of much criticism.

was 2,000 years ago, and a change of level of a few feet would entirely alter its geographical character. This lapse of time, therefore, fails to show any change in the respective levels of sea and land on that part of the coast. Yet the submerged forests can be traced all round our coasts, and they are geologically of quite recent date. This points to not " slight alterations of level between sea and land at various times," but to some cause affecting all our coasts simultaneously, and in the same degree, some cause which has certainly not on the coast of Cornwall been in operation for 2,000 years at least.

The break-up of the glacial period about 7,000 years ago was not only a letting loose of all the pent-up energy of the accumulated ice, but a repayment to the sea of what had been overdrawn during 15,000 years. It has been calculated that the ice piled up on the northern hemisphere was a mass of at least six million cubic miles (some estimates even reach eighteen million cubic miles). The doubling of the first estimate for the two hemispheres is sufficient to lower the ocean more than 200 feet, extending largely our coast boundaries, and permitting the formation of forests and peat, which now that the sea has got its own back again remain permanently submerged. This fact, together with others to be mentioned herein as observable in Scotland, brings the evidence in Great Britain of a quite recent glaciation into conformity with the opinion of American and Swedish geologists.

If there should be an astronomical anomaly or difficulty that seeks for a solution, a reference to the oracle of Drayson seems assured of no uncertain answer. To the enigma of the " acceleration of the moon's mean motion " which has hitherto defied solution, the reply is luminously clear. Again there is a vague hypothesis by which the whole solar system is supposed to be sweeping through space to a point in the constellation of Hercules, rushing to ultimate collision and annihilation. Drayson reassures enquiry, and gives a simple explanation of this illusion, on which his theory has a direct bearing.

The tradition of the Flood encountered in so many different parts of the world acquires a new interpretation, when de Horsey's chart of the obliquity-curve is consulted. It will be seen that round about 5000 B.C. the decrease in obliquity was very rapid. At this time also in mountainous regions the valleys would be in springtime uninhabitable owing to avalanches and mountain torrents.

It seems extremely probable that the lake-dwellings, built on piles, which are generally referred from their culture-stage to about this date, and remains of which have been found in most lake regions of the temperate zone, were not built for greater security from wild beasts,* as supposed, but simply to avoid the cataclysmic conditions of the spring season. Apart from the floods in the valleys, the danger points for

* The Bronze age was then beginning, and their weapons were in greater perfection than ever before. Moreover, the employment of the same engineering skill and material would make formidable and efficient stockades.

avalanches, which even now are numerous and have to be given a wide berth, must have been multiplied to an extent of which we can have no conception. There is evidence to show that the lake-dwellers provided winter quarters for their domestic animals, oxen, sheep, and goats, in the same fashion. This, and the more or less simultaneous abandonment of such dwellings in these regions points to their having been driven to construct them owing to the forces of nature, rather than to considerations of convenience.

The vagaries of the climate have been so capricious that meteorology is at a loss to explain the past conditions or to predict the future, and contents itself, as in the Congress at Rome of 1911, with recording an opinion that there is perhaps some factor making for change.

That this enquiry should have been held at Rome was appropriate, in that the annals of that city could provide a history of the centuries, when the Tiber was occasionally frozen, a condition of climate at the present time inconceivable.*

The Press, too, have much discussed this matter, and are agreed in calling the weather of last year "muddled," *absurde*, or *verrückt*, according to nationality. Had Drayson been consulted, the answer would have been complete and satisfactory.

Part III. is a further explanation of a few aspects of the question, which have been above outlined, and contains a discussion of climatic changes and other matters, as well as a criticism of some of the tenets of astronomy, which in the light of Drayson will have to be revised.

To expect these conclusions to be at once accepted would be to ignore precedent, but, as at the time when the great doctrine of Evolution was heralded, research will be eventually stimulated and organised with far-reaching results in all the branches of prehistoric study.

The various convincing pieces of evidence, as hereafter summarised, show the importance of Drayson's discovery. These, which have been proved and of which any single one is sufficient to warrant an official investigation, contain a concrete fact, which should appeal to the least scientific of enquirers, namely, that while Drayson's movement requires a simultaneous increase and decrease of the ice in polar regions, the ice-fringes at *both* Poles are now in a condition of increasingly rapid retreat. Herewith the outer world is able to come into closer grip with astronomical statements, and to insist on the scrapping of theories, which by the following quotation appear to be no longer tenable.

> "They (geological evidences) assure us no doubt that ice-
> "ages have occurred in both hemispheres, but they leave us un-
> "informed as to whether the ice-ages were consecutive or were
> "concurrent. Now this is not a mere matter of ordinary signifi-
> "cance, as it involves an absolutely vital point in the astronomical
> "theory of the ice-ages. So much so is this the case, that if it

* In 1344 all the Italian rivers were frozen. In 1709 some parts of the Adriatic and of the Mediterranean round Genoa were frozen over.

"could be shown that the ice-ages in the two hemispheres were "concurrent, the astronomical doctrine would have to be *forth-* "*with abandoned.*"—*The Cause of an Ice Age*, by Sir Robert Ball.*

So many concrete statements of fact made in this work have been disputed as if they were mere theories, that the writer feels obliged here to call in the testimony of a geologist, whose name will carry great weight. Professor G. F. Wright, in his *Origin and Antiquity of Man*, states:—

"It was formerly maintained on Croll's astronomical theory "that the glaciation of the southern hemisphere was not con- "temporaneous with that of the northern, but that the glacial "episodes of these two hemispheres followed each other in successive "alternation. . . . But recent observations show that the "glaciation of the two hemispheres was *contemporaneous*."

From the Comparative Summary (page 17) it would seem that a great advance in knowledge has been made by Drayson. Why, then, this antagonism on the part of astronomers? Where do opinions diverge? The whole question really hinges on the fact that the astronomical theory has been built up on the supposed symmetry of the earth. This, after providing a wrong basis for Newton's calculations, has been succeeded by other errors, to which the first error gave birth.

A direct consequence of this assumed symmetry of the earth is to centralise any movements on the ecliptic pole. The precession movement must be, therefore, round this centre; and that is the ground that astronomers take.

Drayson, on the other hand, without being aware of any want of symmetry, which is a recent discovery, attacked astronomy because of its paradox of a moveable centre to a circle—the first error created by the above false assumption—and having successfully found the true centre of movement, discovered that it is the key to many otherwise obscure phenomena.

Incidentally the new curve for the pole of the heavens at once provides a basis for computing the date of the last ice-age, and it is the object of the writer herein to show that the date Drayson gives is the correct one.

All the various aspects of the question will be seen to tend to one conclusion. Firstly, Astronomy gives emphatic evidence against itself, when it speaks of having to abandon its theory on certain contingencies, which it thought never would arise, but which have arisen. Secondly, the inability of astronomers to account satisfactorily for the decrease in obliquity is shown in these pages; whereas Drayson has a complete explanation of this and other celestial phenomena, providing abundant proofs and producing test results, which are absolutely convincing on *prima facie* grounds.

* The assumption therein stated with regard to the dispersion of Arctic flora into southern latitudes, of which much is made, has since been found to be also erroneous. See page 904 *Natural History of Plants* by Kerner von Marilaun (Blackie & Son).

The celestial arena of the conflict is rather remote from the observation of ordinary mortals ; but when it is found that evidence of glacial phenomena, as interpreted by geologists, points conclusively to the same chronology of events as does Drayson's astronomical calendar, the evidence becomes overwhelming that Drayson is right.

There is, moreover, a most important matter that has not as yet engaged the attention of astronomers, namely, that in recent years gyroscopic dynamics have assumed an unsuspected importance, which cannot be astronomically ignored; and one may say that until the motion of the earth has been thoroughly investigated from this point of view astronomy cannot presume to be in possession of a complete knowledge of the precession-curve.

One of the critics of Drayson from a purely orthodox astronomical standpoint writes thus :—

> " When two theories equally account for a given set of
> " phenomena, we must look outside that set of phenomena and
> " prefer that one which is most successful. Success is to be gauged
> " by the ratio of the number of phenomena explained to the number
> " of assumptions made."

If the field in astronomy devoted to an explanation of the glacial periods has had to be abandoned as unworkable, it is hoped that it will not be considered a trespass to enter this field. With this apology the writer asks only for considerate treatment, and is anxious that the question should be duly submitted to the above test.

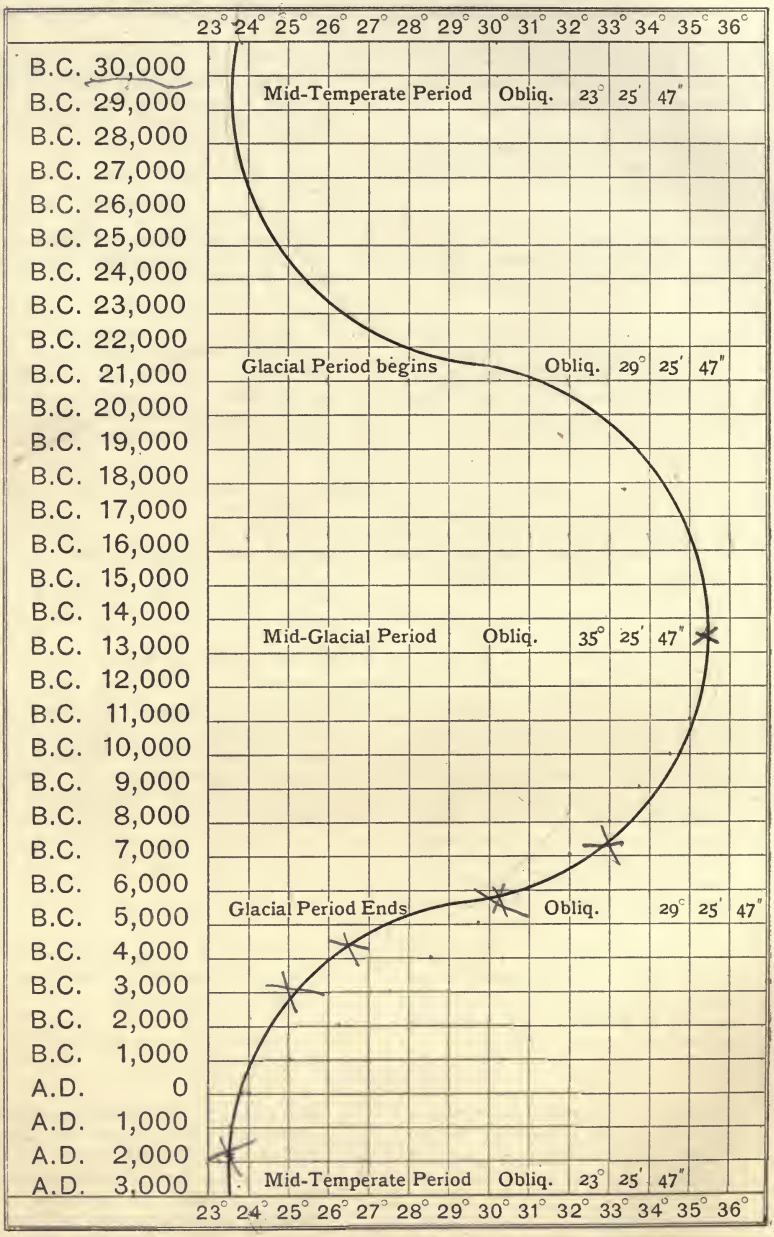
There is some reiteration of the description of Drayson's theory and its results in the different portions of this book, but it has been found that the subject does not come easily into the grasp of the layman, and some readers prefer to approach the subject from one point of view while others understand it more easily from another. Repetition in this case does not obscure the issue, but helps in the long run to a better comprehension of the facts.

A COMPARATIVE SUMMARY.

1. Drayson states, in opposition to astronomy, that the Glacial Periods were contemporaneous at both Poles.	1. The views held by astronomers regarding the Glacial Periods, will, on their own showing, have to be abandoned.
2. Drayson maintained that errors in sidereal time existed, which by his *data* could be corrected. In 1892 the error by Drayson would be 41.28″, according to de Horsey's calculation.	2. Mr. Stone in 1892, then Radcliffe Observer at Oxford, working from a wholly different basis, asserted that sidereal time was incorrect by 41.51 seconds.
3. Drayson can compute the obliquity of the ecliptic for any year, past or future, without observations.	3. This can only be done by astronomers by constant observations during the current year.
4. Drayson, by his *data*, can compute the Right Ascension and Declination of any star for any year, in the past or future, from one observation of that star.	4. Astronomers can, apparently, only do this from several observations at wide intervals, to arrive at a mean for application to the star in question. For an approximate forecast they are limited to a few years ahead.
Drayson's one movement—the annual motion of the Pole—called by him "the second rotation" of the earth, accounts for	(*a*) The progressive decrease in obliquity and its rate. (*b*) The time and duration of the Ice Ages. (*c*) The changes in the co-latitude of stars. (*d*) The error in sidereal time.
5. Drayson shows that the supposed movement of the entire solar system is only apparent since the effect is produced by the motions of the pole of the heavens towards the culmination point of maximum obliquity, the position of which accords closely with the mean of several astronomical observations directed to ascertain *the apex of solar motion*.	5. It is generally accepted by Astronomers that the whole solar system is moving at a definite speed towards a point in the constellation of Hercules which is termed "the apex of solar motion."
6. Drayson shows that a complete explanation of the enigma of the acceleration of the moon's mean motion is furnished by adopting his centre of polar motion.	6. "Gravitation alone is incompetent to explain completely the observed motion of the moon." "Astronomy is at a standstill for an explanation."
7. Drayson, giving precise dates, states that the last glaciation began 23,700 B.C., and came to an end in 5624 B.C.	7. Croll's theory, which has the support of astronomers, states that the Glacial Period began 240,000 years ago, and came to an end 80,000 years ago. From evidence in America and Sweden, geologists reckon that it passed away some 7,000 years ago, and agree generally with Professor Prestwich's opinion that it only lasted some 25,000 years in all.

THE OBLIQUITY CURVE DURING A CYCLE OF 31,756 YEARS.

Shewing the commencement, duration, and termination of last Glacial Period.



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Part I.

WHY WE MAY EXPECT WARMER WINTERS.

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WHY WE MAY EXPECT WARMER WINTERS.

One point only is clear, that the ultimate controlling factor, the one which there is the least hope of being able to modify in any way—and therefore the one we need to know most about—is Climate ("CLIMATE AND WEATHER," by Prof. H. N. DICKSON (Home University Library).

THE writer proposes to show in this paper how time has justified the conclusions of a scientific man who has recently passed away, Major-General A. W. Drayson, and to place before the public facts which will enable them to form a just opinion of the theory put forward by him. Had it been a question between him and any other scientific body of men, he would ere this have had a hearing, but the reverence which naturally and rightly is ascribed to the most abstruse of all sciences has hitherto stood in the way of justice being done to him, and of anyone but an expert taking up the cudgels on his behalf. When it is remembered that the conclusions of Pythagoras remained for 2,000 years before they were accepted, namely, those relative to the earth's daily rotation, it would not be surprising if a man even in the 19th century were to fail to get a true theory accepted during his lifetime.

As Mr. A. R. Wallace rightly says, no scientific truth of any importance has ever been accepted without a struggle and without opposition of the most unreasoning kind in every department of science ; and it would be strange, were it not so in the case under consideration. We are apt to think that our generation is at the end of time, when perhaps we are only, as the human race, on Time's threshold, it is therefore foolish to suppose that established theories are unassailable and incapable of demolition.

To strengthen respect for the theory in question it can be stated that Major-General Drayson, a man of undoubted talent in many departments, in this particular field of astronomy achieved many unrecorded triumphs. When a comparatively young man he was the first to ascribe the true reason for the behaviour of the satellites of Uranus, though he did not obtain the credit for it. In his writings many years ago, he states that owing to the lack of knowledge of the second rotation of the earth the precision of prediction for solar eclipses would in certain latitudes be impaired. The writer was informed by one of the party employed in the observation of the last total eclipse in India, that there was some dis-

crepancy between the predicted and the actual time. Further, elsewhere in his writings he predicted that the rate of precession of the equinoxes, which was regarded by astronomers as a constant, would some day have to be altered. This constant was altered the year that Drayson died.

Finally, and this was the climax clinching the present theory of the second rotation, which has impelled the writer, though a layman, to make an effort towards obtaining a hearing for him ; namely, that Capt. Scott on return from the Antarctic expedition emphasised the rapidity with which the south-polar ice was retreating. It is a well-known fact that in the northern regions a similar condition of things is taking place. Now Drayson's theory of a second rotation requires this, but the official theory requiring opposite conditions, viz., advance of ice at one Pole to correspond with ice retreat at the opposite Pole, must thereby be completely set aside. It may be that astronomers, knowing the strength of their position, may not have hitherto deigned to cross swords with him, but the evidences in his favour have accumulated to an extent that demands some official dictum. Not only the evidence on which Drayson relies, that of bringing foreknowledge to bear on problems that at present can only be treated empirically, but many other facts can be arrayed in his favour. The abrupt transition from Palœolithic to Neolithic remains of prehistoric man ; the juxtaposition of arctic and tropical fossils ; the prehistoric influx of the Aryan race into Northern Europe ; the computations of geologists regarding the date of glaciation ; and finally the apparently recent traces of ice action everywhere, all combine to accord him credence.

The writer would here like to remark that as a geologist he has for a long time felt the force of the probability that Drayson's explanation of the glacial period was the correct one ; so much so, that this pamphlet was written throughout with the conviction that the final test of the truth of it would not fail when applied to the actualities of the present time. This conviction, it will be seen, was borne out by the application of Drayson's data to the year 1910, and its comparison with the observations as recorded in the Royal Observatory for 1910, which latter themselves falsify the pronouncement of astronomers regarding the variation of the obliquity of the ecliptic within small limits only. A knowledge that a change is taking place in the direction of milder winters is of such great economic importance that it is well worth while to definitely establish. For us it is more of a question for the land cultivator, though many minor interests are involved, but to the vast areas now being opened up in Canada the matter is in the highest degree important. Quite recently at a lecture Dr. Grenfell spoke of a large scheme for opening up the interior of Labrador. Such a venture would, in the face of this certainty of " betterment," lose half its risk. The matter can no longer be treated as an academical question, but appears as one which there is an immediate interest in verifying. The contents of this pamphlet amply provide the answer with both scientific and mathematical accuracy.

FORMER CONDITIONS OF CLIMATE.

That the winters in these latitudes are gradually and perceptibly getting milder is a matter of universal comment. Is it what we call chance or is it due to some fact in astronomy or physical geography, that we are in a position to ascertain ?

The seasons, winter and summer, are due to the position of obliquity of the earth's axis. It is reasonable to suppose that if a uniform change is taking place in the seasons the position of the axis has something to do with it. We know that at some period before history began, occurred the Ice Age or Glacial Period, when the whole of the northern hemisphere down to our latitudes was invaded by ice, and that an ice sheet lapped over the east coast as far south as Suffolk, while other blocks borne by land ice were stranded close to London at Highgate. Now, there must be a definite reason for this state of things. It was no casual occurrence because there are distinct traces of three or more successive glacial periods stamped on the rocks, and recognised by geologists. Has this former severity of the winter seasons anything to do with the position of the earth's axis ? What do astronomers tell us ?

Briefly, astronomers have not hitherto admitted any important change in the obliquity of the axis of the earth, but ascribe the occurrence of the glacial periods to a combination of aphelion conditions with a change in the direction (not obliquity) of the earth's axis. This only occurs after vast periods of time, the last ice maximum having been reached 240,000 years ago, and the last ice period having finally passed away some 80,000 years ago in the northern hemisphere. It is important to observe that according to them cold conditions in the North Arctic corresponded in time with genial conditions in the South Arctic, and *vice versa*. This idea has now been falsified by the observation of the South Arctic expedition.

The above is not at all satisfying to some geologists, as the evidences of a much more recent time than 80,000 years ago are plain and convincing. Rocks smoothed and marked by ice and then subjected to weathering by the elements and further disintegration by vegetable life, could not after 80,000 years look as if they had been laid bare only yesterday ; and the signs are everywhere and too numerous for the assertion that the rocks have been preserved fresh under deposits of other material, and have so escaped weathering.

Geologists have, however, done what they could. Without any unit of time they have had recourse to other methods, and by investigations regarding the retrogression of the Falls of Niagara and of the St. Anthony and corresponding geological evidence, have arrived at results which placed the age of ice not many thousand years back, in no case exceeding 30,000 ; and indeed the mean of three separate computations gives a

round figure of 15,000 years ago as the date of the glaciation. The important corroboration which this furnishes to the subject of this pamphlet will be seen hereafter.

Geologists and astronomers are thus at variance. The latter can give the former no definite assistance, and, indeed, have never given any very exact account of the time required for one of the factors that they reckon on, namely, the revolution of the earth's axis, to complete its cycle. The cycle of revolution has been variously stated during the last thirty years, as it has been based on an observed rate of change which has never been a uniform one.

Accustomed as we are to the achievements in precision of astronomers in other directions, this vagueness comes somewhat as a surprise, and when certain statements bearing the stamp of authority are regarded more closely their ambiguity is certainly remarkable, and astronomers cannot complain if they are called in question.

DRAYSON'S THEORY.

It is now proposed to give an account of the work of Major-General Drayson, entitled *The Earth's Past History* (Chapman and Hall), published in 1888, in which he traverses the position taken by astronomers regarding the movement of the earth's axis, and states that the earth has a second rotation besides the diurnal one, and that he has computed all the elements of this second rotation. He also adduces proofs of this by his ability to make certain astronomical calculations that are at present beyond the power of astronomers to work out.

Briefly he accounts with his second rotation for a cycle of 31,682 years, during which the obliquity of the earth's axis varies from a minimum of 23° 25′ 47″ to a maximum of 35° 25′ 47″. The important point of this is that we are now some 15,450 years removed from the height of the Glacial Period, when the contrast between summer and winter in temperate latitudes was inconceivably great, and only 385 years removed from the position of minimum obliquity when the contrast between the seasons will be least. This, it will be seen, is of immediate interest for us.

Many years ago, when he was a Professor at the Woolwich Academy, a question was asked him by a cadet, which first called his attention to certain conflicting statements regarding the movement of the earth's axis, or as it is usually styled, the " pole of the heavens." The statements in question are first, that we are told that the earth's axis traces a circle round the pole of the ecliptic *as a centre* keeping constantly at the same distance from it of 23° 28′ (Sir John Herchell's Outlines of

Astronomy, Art. 316). Then we are told that it does vary its distance from this centre to the amount of 48″ or 46″ per century !

These statements seemed to Drayson so unsatisfactory that he set himself to study and find out what was the real centre round which the pole of the heavens (the earth's axis) revolved, and after some twenty-five years of investigation he arrived at the following most important conclusion :—

Whilst there is a rapid or daily rotation of the earth taking place round an axis which is fixed in the earth, there is also a slow rotation round a second axis which is not fixed in the earth, but appears fixed as regards the heavens. This second rotation causes the two *semi-axes* of the earth to describe cones during one slow rotation, just as the earth's daily rotation causes a line from any locality to the earth's centre to describe a cone during twenty-four hours.

The conical movement of the semi-axes is in accordance with what one would naturally expect if a second rotation has been imparted to the globe ; and Drayson gives us the real centre, not the shifting centre, round which the earth's axis revolves, and this is 6° removed from the pole of the ecliptic. (See Frontispiece.)

In the words of Drayson : " The pole of the second axis of rotation is " distant from the pole of the heavens 29° 25′ 47″, and is situated not " very far from a celestial meridian of eighteen hours, or 270° of right " ascension."

The consequence of this discovery is of manifold importance. For the purpose of this pamphlet only one feature, the variation in the obliquity of the ecliptic, that is the angle of the earth's axis to the plane of its orbit, will be considered.

We have here a very different movement. No longer can the earth's axis be stated to practically maintain the same angle through all time—*i.e.*, through an entire revolution of the equinoxes, but is uniformly changing from a maximum obliquity of 35° 25′ 47″ to a minimum obliquity of 23° 25′ 47″. The former would entail very hot summers in combination with very cold winters, a condition indisputably requisite for the rapid evaporation of moisture for transference to the polar regions as snow*.

Effect of Maximum Obliquity.

This maximum obliquity, which took place in 13,544 B.C., was the culminating point of the Glacial Period. All latitudes greater than 54° 34′ 13″ would therefore have been within the arctic circle. In other words, all places immediately to the north of Yorkshire would have been under the present climatic conditions of Nova Zembla and Northern Greenland, whilst at midsummer similar latitudes would have been subjected to a tropical summer. At midsummer the sun's meridian altitude would be 70° 25′ 47″, that is 12° greater than at present : but

* See Appendix to Part I.

the sun during twenty-four hours would not set, and a midnight sun would therefore be visible from all parts of Scotland.

In midwinter, on the other hand, the sun would not rise above the horizon of latitudes of 55° and upwards during several days, and the whole of Scotland and the north of England would suffer from an arctic climate. The evidence of glaciers and of large masses of ice having been formed, and of boulders having been carried by this ice into distant localities as far south as Middlesex is in accord with this. In North America, owing to a different distribution of land and sea, the evidences of ice action extend even to latitudes of 40° ; and in Alpine regions the volume of ice was so enormous that blocks from the Alps were carried over the high mountains of the Jura to great distances beyond them.

This is all a matter of precise geological history, but without these new astronomical data, the period assigned by astronomy has been too remote to provide an efficient unit wherewith to measure geological time. Such computations as have hitherto been made by geologists have lacked the support of astronomers, and their ardour of research has thus been cooled by the apparent impossibility of arriving at a working agreement. Their efforts in this direction in the light of the theory of Drayson, however, bear a very different complexion, and the preciseness of their conclusions are a striking testimony to the truth of geological presumptions.

While the date 13,544 B.C. marks the date when glaciation was at its height, the date 5,624 B.C. marks the time when the northern hemisphere began to enter into milder conditions. From that time forward the change was probably rapid. When once the ice began to melt vast regions in our latitudes must have been in a condition when the summer sun could overcome the well-known resistance of ice to melting, the so-called *latent heat*. The resulting deluge owing to overflowing rivers and the bursting of ice barriers might well have spread universal terror, carrying destruction even to southern latitudes, causing the survivors to hand down the dread tradition to future generations of mankind.

The disaster which occurred some years ago at St. Gervais in the Alps, when the Bionassay Glacier, which pent up the waters of melting ice until they formed a large lake, and whose ice barriers finally gave way under the strain, is an apt illustration of conditions that must have been everywhere prevalent. Moreover, the theory states that the rate of change of obliquity is not uniform, but was more rapid just at that period 5,624 B.C. of the cycle, than it is now. (See page 18.)

That the tradition should be so universal in both hemispheres need no longer cause surprise. The comparatively recent date of the cataclysmic conditions would account for the preservation of it, whereas if the change had taken place 80,000 years ago, as according to astronomers, the tradition of the event could hardly have been maintained down to historical times.

That the ancients had some faint knowledge of this great change would appear from the fact that Aristotle mentions that the Chaldæans had a belief of a period termed " a great year (or period)" during the summer of which there was an *ekpyrosis* or conflagration, and during the winter a *kataclysmos* or deluge.

ETHNOLOGICAL AND OTHER EVIDENCES.

After this date, when the climate of middle latitudes became more equable, took place that vast migration of the human race, as testified by tradition and language, and man spread through Asia Minor from the sub-tropical regions into Central Europe. Here again is not our vision of the past considerably cleared and enlightened ? We know now why, while from time to time we discover in southern climes civilisation and records earlier than our forefathers ever guessed to be possible, we never find traces of a corresponding civilisation further north. Indeed, the traces of the organised worship at Stonehenge has striking affinities with other such places in the Mediterranean only, and may perhaps be traceable to the Minoan civilisation as found in Crete.

Many geological facts otherwise puzzling receive their solution. Most of our knowledge regarding prehistoric man is gathered from cave deposits, and though we may safely say that they have covered a period of many thousands of years the deposits do not show a gradual and uniform improvement in the intelligence and crafts of the cave man. Everywhere there is a break,* an abrupt transition from deposits of chipped flints and tools of the roughest type to others of a much more advanced nature. It is rendered clear why. While for thousands of years the cave man of the north was at grip with conditions of climate and surroundings, like the Eskimos of to-day, which made life one long struggle for self-preservation, his fellow-man of the south was able to advance greatly in civilisation. Thus, when the time was ripe and genial conditions returned, the latter was able to bring with him better weapons and a superior organisation, ousting Palæolithic man from his hunting grounds, and driving him ever northwards into regions where his descendants alone could exist.

Another geological enigma receives an explanation. Sir Charles Lyell says : " But we find in some parts of the drift evidence of a conflicting character, such as may suggest the idea of the intercalation of more genial seasons of sufficient duration to allow of the migration and temporary settlement of species coming from another and more southern province of mammalia, so that their remains were buried in river gravel,

* Dr. Sturge shows that the sterile layers in the caves denoting the gap in human history may have been caused by a general arid or steppe-like condition of this part of the world.

at the same level as the bones of animals and shells of a more northern climate."

To the reader unacquainted with the second rotation of the earth and of the climate that prevailed at the date 13,544 B.C., all the facts stated would be mysterious and unaccountable.

The extinction of so widespread a species as the mammoth co-temporaneous with man is scarcely explicable with ordinary conditions ; but we can now see how the mammoths having become specialised as a northern animal, adapted to the assimilation of northern vegetation, and requiring copious supplies of it, were absolutely helpless in face of the advancing ice sheet and disappeared from the earth, leaving their remains in certain localities in astounding quantities. An analogous catastrophe occurred in Texas in 1844-5, when the buffaloes, which were accustomed to regularly visit the Larimie plains, were in an exceptional winter overtaken by the elements, and perished together in hundreds of thousands.

To the student of the past doubtless the solution of many other conundrums will suggest themselves from time to time, and all students of geology will welcome an authoritative statement from a sister science which is so much more in accord with the evidence of the senses than any that has hitherto been offered as an explanation.

Evidences of Recent Ice Action.

Take any one of the hundreds of districts where former ice action can be studied, and it will be seen to respond to the new data. Take the neighbourhood of Loch Etive, for instance. Those ice-worn sentinels at its upper gate, at the inflow of the Awe, seem by their still unclothed appearance to have lately cast aside their mantle of ice. No, not lately, it must not be said. It was, we are told, 80,000 years ago ! The lip of the basin, scooped out by the Etive glacier in its lower reaches, still at every ebb is overflowed by masses of foaming water, forming the falls of Lora. The rock material of the lip is certainly hard, but it still presents the appearance of a lip, there is no marked erosion of the central portion by the action of the river, which such a lapse of time would cause. Not far removed from this, at Ganavan beach, are rocks washed by the waves, but the waves have not beaten on them long enough to obliterate the unmistakeable paring and smoothing of its conglomerate pebbles by the ice of 80,000 years ago ! Across the loch on the slopes of Morven the limestone bed of a departed glacier presents in places almost the same appearance as the rocks flanking the now retiring glaciers of the Alps, but with just sufficient growth and spread of humus in the hollows as would appear reasonable, if the date assigned is only reckoned in units of thousands. Once accept the new data, and one feels one is dealing with obtrusive fact, not with hazy imaginings.

In these regions it may well be that a glacier were here less than 7,000 years ago, and in the Pass of Glencoe at even a more recent date still.

In Norway the ice signs seem astoundingly recent, and in accord with the above suggestion, being in so much more northern latitudes; but here there is a further phenomenon furnished by the numerous waterfalls. In nearly every case the fall takes place over a straight edge of the rock bed, sometimes scarcely even forming a runnel for itself, giving a peculiar character to Norwegian falls, and indicating that the time which has elapsed since their beginnings cannot be a long one.

Evidences of a Coming Change.

We may now proceed to discuss conditions in our own day. It is possible that it never occurred to Drayson that attention might be called to his theory by the direct evidence of the senses so shortly after his publication of it, and that one generation might be able to record a change, even when the cycle of change requires some 15,000 years between maximum and minimum, but this appears to have happened. The year 2295 A.D. marks the apex of the genial period when the contrast between winter and summer is least, owing to the obliquity of the earth's axis being least. This year A.D. is only 385 years ahead of us, and one might reasonably expect each century of approach to this to show some slight modification of climate; but what has actually happened? The change in a generation has been quite appreciable. The glaciers of the Alps began to recede some sixty years ago, steadily and uniformly; and our winters can no longer be pictured as bringing a mantle of snow and periods of continued frost.* The change is too marked in the seasons to be dismissed as a casual incident. Some write that the Gulf stream has increased in volume, but so far it is only surmise, and is moreover extremely improbable, so that will not do.

The real explanation is that though the change is slow and gradual, the effects are not so, owing to the before-mentioned latent heat of ice. Briefly, a mass of ice will not melt until the whole of it is brought up to a temperature of 32° Fahrenheit, and further it requires 79 times more heat to be expended to convert ice to water than it does to raise the temperature of ice one degree, so that ice for long resists the blandishments of the sun, but when a certain amount of heat has been locked up within the ice, it succumbs on slight provocation. Thus ice within the Arctic circle though for years and years it has been lowered in winter to a temperature which the summer sun cannot overcome, eventually through milder winters is less able to combat effectually the sun's rays, and at last begins to melt with great freedom; this process is well supported by evidence.

Some eight years ago or more the fishermen of Grimsby encountered floating ice in great quantities round the Faroe Islands, which till then

* With reference to this it has been remarked that Julius Cæsar continually writes of frosts, which enabled whole nations and armies to cross large rivers in Gaul. Such frosts belong to a climate, which has long since passed away, as has the possibility of conditions permitting a Fair to be held on the frozen Thames at London Bridge.

had been an unknown feature, but latterly has been a usual one. The prevalence of floating ice has been remarked by skippers on various routes, and the following is an extract from an article in Nash's Magazine for February, entitled, " Bagging Arctic Monsters with Rope and Camera " (Paul J. Rainey):—" One thing that surprised us on the Labrador coast was that we saw very little ice; in fact the Moravian missionaries told us that there had not been a season in over a hundred years when the ice had gone out as early as May." . . . The ice referred to is that round the coasts which breaks up in spring into large sheets or pans and starts on its journey south. Again the *Daily Mail* of February 6th announces that a huge ice field has broken off the Viborg coast, carrying a settlement of 250 fishermen with it. This denotes some quite unlooked-for change in the conditions.

In an article on Canadian wheat-growing in the *World's Work* it is remarked that certain lands bordering the north had been hitherto reputed too ice-bound for agricultural operations, but large tracts had been now found, owing to some change that had taken place, to present favourable climatic conditions. That the signs are everywhere there is little doubt. Iceland now belies its name, for the writer has a private letter from that island stating that at that date, mid-December, 1910, there was no snow and scarcely any frost.

A critic might assert that whatever the properties of ice, the ice fringe can only recede *pari passu* with the change of obliquity if it exists, and there can be no sudden change. This would be true if the conditions on the Arctic circle were uniform, if all land and sea were at the same level, and there were no warm and cold streams. Perhaps the following illustration of what has happened in our latitudes will serve to illustrate the changes now probably taking place near the Arctic circle :—

The high-lying valley of the Gemmi Pass, which is, so to speak, an upland valley or basin of the Alps, cut off by a precipitous descent from continuity with the lower valleys, shows signs of having been occupied by a glacier and comparatively quite recently. The recent traces of this glacier do not extend lower than about 7,000 feet, and one can see why in the light of what has been said about the melting of ice, the marks are so apparent.

Long after the Alpine glaciers had withdrawn themselves from the ice sheet and dwindled away each to its own valley preparatory in most instances to disappearing altogether, there remained some ice basins ranging from 7,000 to 8,000 feet, which from their height above the sea level and from their low winter temperature were impervious to the summer sun. This condition lasted through many untold years, but the end came at length, and when resistance to the sun was once weakened to a certain point, the end must have come very rapidly. Take all the conditions of the Arctic fringe, may it not be that large tracts of ice have lately arrived at the parlous condition which allowed short shrift

to the Gemmi glacier? Hence the breaking up and transport of ice in the spring into waters to which they have hitherto been strangers. Hence the increasingly cold spells of spring which come to spite us for the loss of their winter sport. Hence, too, the chilly days of midsummer, which seem to be more frequent.

The seasons we shall always have—Jupiter with no obliquity has none—but they are bound to become milder, and the polar ice caps to be reduced in extent. How far this process will go we cannot yet know; but, at any rate, it has now become a practical problem and will be found especially in northern Canada and Siberia to be one of immense economic interest.

Future Ice Ages.

This theory accounts succinctly for the Glacial Periods of times gone by; it remains yet to be explained why there are evidences of subtropical vegetation having prevailed in former times so far north as 70° latitude. The answer may be found in a movement of the pole of second rotation, which cannot remain through all time at the same point.* On such matters we must be content to remain for the present in ignorance; but of one thing we may be sure, namely, that the past ice ages are full of significance for mankind, for they are bound to recur.

Later the time will come when regions nearer the Equator than are the lands of the progressive northern nations, can alone furnish a field for the maintenance of the life activities of the present age. The last ice sheet, which spread over the haunts of a once much more abundant Tertiary fauna, left but comparatively few survivors. When the next Ice Age holds us in its grip, it will both narrow the habitable portions of the globe and cramp the energies of the human race. Whether the north will transfer its activity to the plateaus of Central Africa and Asia or succumb before the darker races nearer the Equator, is happily not yet a question that requires a solution.

THE FINAL PROOF.

It may seem an impertinence to cast a doubt upon any statement of the most exact of the exact sciences, but, after all, the proof of the pudding is not in the ingredients themselves, but in the final test of assimilation; and here, it seems, that Drayson achieves a veritable triumph.

Armed with the key to the cipher, he computes with ease the polar distances of stars for any date, the obliquity for any date of future or past time, and comparing his results with the official ones, is able to congratulate astronomers on the accuracy of their observations from the

* See *Movements of the Centre of Second Rotation*, page 73.

lofty standpoint of being himself freed from the necessity of such frequent scrutiny of the celestial motions.

The writer has tested for himself his ability to use Drayson's data of second rotation to find the obliquity for 1910. This, a simple calculation in spherical trigonometry, when worked out proved to be 23° 27′ 4″.7. (*See* Appendix.) The only recorded obliquity known to the writer at the time was that of 23° 27′ 25″ of about twenty years ago.

On applying to the Astronomer Royal for the official statement of the obliquity, the answer was as follows :—

" *I have to inform you that observations of the sun for the purpose of ascertaining the obliquity of the earth's axis are made continuously at Greenwich. In* 1910 *the inclination may be taken as* 23° 27′ 3″.6. *For* 1909 *it was* 23° 27′ 4″.0. *It changes very slowly.*"

Notice the admission, that the elements of the curve of revolution of the axis are so little known that observations have to be made continuously whereas anyone knowing the elements of the second rotation can arrive at very approximate results by calculation in his own study. Considering that these data were found by a man working single-handed in a vast unknown field, it appears a truly remarkable approximation.

The above result fully establishes the truth of Drayson's theory, as it differs only eleven-tenths of a second from the official one, though obtained by a calculation, which starts from a date 385 years distant. 2295.2 A.D. is the exact date when the obliquity, according to Drayson, is least. Astronomers, on the other hand, are unable to foretell for future years what the obliquity will be, and Nautical Tables have to be revised from time to time by actual observation.

It is submitted that this final test, after the foregoing reasoning, is conclusive. There is also proof that in this matter of obliquity orthodox astronomy has not yet found its bearings.

An Astronomical Statement regarding the Obliquity of the Ecliptic.

The following, taken from *Astronomy*, by Sir Robert Ball, published in 1890, may be regarded as the view accepted by astronomers, and is in the light of the very different value for the obliquity now given for 1910, indicative of the great uncertainty under which they labour.

Sir Robert Ball, after giving the following obliquities as determined in the years between 1847 and 1877 :—

June 21, 1847	23°	27′	23″.56
,, 1857	23°	27′	37″.12
,, 1867	23°	27′	13″.05
,, 1877	23°	27′	26″.51

goes on to say :—

" It would not be correct to say that the obliquity was absolutely constant, yet the changes in its value are extremely small. In fact, the

mean of the four values just given is

23° 27′ 25″.26,

and the difference between this quantity and the greatest or least of the four observed values is only about one seven-thousandth part of the total amount.

We are thus led to the conclusion that whatever be the motion of the equator among the stars *it constantly preserves the same inclination to the ecliptic.*" (The italics are the writer's.)

But, according to the Astronomer Royal, the obliquity for 1910 "may be taken as "

23° 27′ 3″.6.

The direct contradiction of the foregoing statement, by the above result of observation twenty years afterwards is a striking proof that the official position is a very questionable one. There is, however, a still more forcible contradiction to follow.

It will be observed that the movements of the obliquities for the different decades are very irregular, and assuming that they are correct, (though such plus and minus irregularities are extremely improbable), it would weaken the position for Drayson to some extent.

There is, however, a later edition for 1909, which gives the following obliquities, most satisfactorily bearing out the theory of progressive decrease, viz. :—

Jan. 1, 1870	23°	27′	22″.31
,, 1880	23°	27′	17″.55
,, 1890	23°	27′	12″.79
,, 1900	23°	27′	8″.03

Commenting on these figures exactly the same argument is employed to show the permanent character of the obliquity in these words. " It would not be correct to say that the obliquity was absolutely constant, yet the changes in its value are extremely small. In fact the mean of the four values is

23° 27′ 15″.17

and the difference between this quantity and the greatest or least of the four observed values is only about one twelve-thousandth part of the total amount. We are thus led to the conclusion, etc."*

If we here call in the aid of the doctrine of probabilities, at times found so useful by astronomers to give emphasis to their conclusions, it would be interesting to have a statement based thereon, to show the probability in favour of the earth's axis constantly preserving the same inclination to the ecliptic, as against the probability of the progressive decrease demanded by the theory of Drayson.

* The earliest recorded obliquity was at the beginning of the Christian Era and was 24°. This has presumably been disregarded as incorrect, but it is quite in agreement with the new theory, as are also the obliquities for A.D. 1590 and 1690, which were stated to be, for 1590 23° 29′ 52″, and for 1690 23° 28′ 48″. The writer has been supplied with the following table of obliquities from the Greenwich Observatory for the remaining decades beginning with 1830, viz.:—

1830	23°	27′	42·5
1840	,,	,,	36·52
1850	,,	,,	31·95
1860	,,	,,	27·38

APPENDIX TO PART I.

It may interest the reader to be furnished with a reason for the pertinacity with which the idea of a constant obliquity is held, in the face of evidence to the contrary. Sir Isaac Newton had presented to him the phenomenon of the precession of the equinoxes, caused it was said by the movement of the pole of the heavens round the pole of the ecliptic. He therefore, brought his mathematical armoury to bear on the problem, with the result that he was able to ascribe this movement to the joint action of the sun and moon on the protuberance of the earth's equator.

The reasoning seems convincing, but it depends entirely on the fact of the earth's axis describing a circle round the pole of the ecliptic as a centre. The whole argument must collapse, if this point is not the centre, and there will have to be a complete reconstruction of fundamental ideas.

The various points on the equator will still in turn do duty as the equinoctial, but the protuberance of the equatorial belt, except in so far as it accounts for the small movement of "*Nutation*," may now have to retire from public service.

Experience of rotatory forces and the behaviour of the gyroscope tend to make one more readily admit the probability of a second slow rotation, while there really is no reason for supposing that such a rotation *must* be symmetrical with respect to the ecliptic.

Change of Obliquity said to be not real.

Though the diminishing obliquity is recognised by astronomers, it is stated only to be *apparent* in that "the place of the ecliptic in the heavens is not absolutely constant. The ecliptic, in fact, is inclined $1\frac{1}{2}$ degrees to the invariable plane, and this inclination is undergoing a slow process of change." This is fully dealt with on page 63.

Hot Summers Necessary for a Glacial Period.

The necessity of a combination of hot summers with cold winters for ice production may not be at once apparent, but the following quotation from *Prehistoric Times* (by Sir John Lubbock) states the reason clearly :—

> " To produce snow requires both heat and cold—the first to cause evaporation, the second to produce condensation. In fact, what we require is a greater contrast between the temperature of the tropics and of our latitudes ; so that, paradoxical as it may appear, the primary cause of the Glacial Epoch may be, after all, in elevation of temperature to the tropics, causing a greater amount of evaporation in equatorial regions, and consequently a greater supply of the raw material of snow in the temperate regions during winter months."

Again, Professor Tyndall, referring to ancient glaciers, says :— " Cold will not produce glaciers. You may have the bitterest north-east winds in London throughout winter without a single flake of snow. Cold must have a fitting object to operate upon, and this object—the aqueous vapour of the air—is the direct product of heat. It is perfectly manifest that by weakening the sun's action, either through a defect of emission, or by the steeping of the entire solar system in space of a low temperature, we should be cutting off the glaciers at their source."

The Only Hitherto Recognised Cause of Glacial Periods.

Reference has been made to the theory which is held generally, though not very enthusiastically, as giving the only astronomical reason which is able to be furnished for the occurrence of glacial periods, namely, that put forward in the first instance by Dr. James Croll and afterwards shaped to this end by meteorological considerations. The theory is based on the rhythmical movements of our planets' orbit from a circular to an elliptical form, owing to the influence of the other planets ; that is from conditions of perihelion to aphelion, by which the earth, which is now nearer to the sun in winter as regards the northern hemisphere, was a long time ago at the farthest point possible (in aphelion) at this season.

It is stated that under all circumstances 63 % of the total heat on the hemisphere must be received in summer and 37 % in the winter, so that in the extreme condition of aphelion, when the summer is of 166 days' duration and the winter of 199 days, 37 % of the total heat received, in winter has to be spread over this latter period, producing long and cold winters, enabling the winter deposit of snow and ice to increase from year to year. The correspondingly short summer, receiving 63 % of the heat, would be very hot, causing the evaporation necessary for a great accumulation of vapour to be precipitated as snow in the following winter. According to this theory the glacial condition would have been at its height 240,000 years ago, a condition from which the earth emerged about 80,000 years back.

How far this statement regarding the total heat distribution may be true in practice, the actual amount of heat withdrawn from circulation during the winter is small, as the maximum reduction of the heat in aphelion is stated to amount only to the difference between 31 and 29 heat units for the winter season. It has been stated in support of this theory that the heat unit is of great significance, as it here represents the mean daily heat received from the sun, by which the earth is warmed up from the temperature of space ; so that the heat unit maintains a temperature perhaps 300° above what the earth would have without that heat. In view of the high constitutional temperature of the earth, this statement appears strained.

When all has been said in favour of this hypothesis, and the mathematically deduced laws regarding the heat distribution as mentioned above, there still remains the fatal objection that in accordance with the theoretical reasoning the South Arctic fringe now in aphelion in winter, ought to be enlarging its borders instead of rapidly retreating as is now known to be the case.

The more this direct piece of evidence is considered the stronger is the presumption that the only adequate explanation of the occurrence of an ice sheet, which wiped half Europe off the map, is a greater obliquity, and the change of obliquity to the amount of 12° would incontestably produce such a result, causing an alternate increase and decrease of the snow caps, synchronous in time at both poles and of practically equal extent.

This pamphlet has been written with the sole view of unravelling the problem of the change of climates, which the earth is known to have passed through ; but it is not this enigma alone that the Drayson theory is capable of solving. The declination and right ascension of stars are undergoing variations, which are neither alike for different stars nor uniform for any star. The right interpretation of these motions is likewise outlined by this theory, responding as fully to the cipher-key of the second rotation, as do the rock tablets and records of the bygone dynasties of the ice.

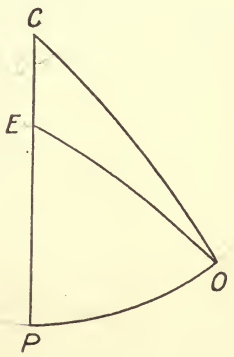
Calculation of Obliquity for 1910 on Drayson's Data.

Referring to diagram below, C represents the pole of second rotation, E the pole of the ecliptic, P the pole of daily rotation at the date 2295 A.D

CE = 6° CP = 29° 25′ 47″

EP = 23° 25′ 47″

Annual decrease
of angle OCP = 40″.9 (Drayson).



O represents the position of the pole of daily rotation, so to find the value of the angle PCO for any date, say 1910, we must subtract 1910 from 2295, the date when the angle will be zero, and we obtain 385 years. Multiply 385 by 40″.9, the annual decrease, and we obtain 4° 22′ 26″.5 for the angle ECO for Jan. 1st, 1910.

We now have CE = 6°, a constant, CO = 29° 25′ 47″, also a constant, and the included angle ECO = 4° 22′ 26″.5, to find the third side OE, which is the angular distance of the pole of the heavens from the pole of the ecliptic on Jan. 1st, 1910, and is therefore the measure of the obliquity at that date.

Adopting the ordinary formula, the following is the calculation :—

Log cosine 4° 22′ 26″.5 = 9.9987333 −10
Log tan 6° = 9.0216202 −10

9.0203535

9.0200324 = Log tan 5° 58′ 57.5, 1st arc
CO = 29° 25′ 47″
5° 58′ 57″.5

23° 26′ 49″.5 2nd arc.

Log cosine	23°	26′	49″.5	=9.9625720
Log cosine	6°			9.9976143
				19.9601863
Log cosine	5°	58′	57″.5	=9.9976282
				9.9625581 =Log cosine 23° 27′ 4″.7

The mean obliquity given by the Astronomer Royal for 1910 was 23° 27′ 3″.6. This represents the mean result after allowing for the semi-annual irregularities of the Nutation movement, owing to the periodic attraction of the moon on the equatorial protuberance. The mean value for 1909 23° 27′ 4″, which presumably is the value best compared with January, 1910, is still nearer the above result on Drayson's data, the difference amounting to only seven-tenths of a second!

March, 1911.

Part II.

A FURTHER EXPLANATION

OF THE

DRAYSON THEORY

WITH

CONFIRMATORY EVIDENCE FROM OTHER SOURCES

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FURTHER EXPLANATION OF DRAYSON'S THEORY.

Scientific method is simply the exercise of common sense. It is not a peculiar, unique, professional, or mysterious process of the understanding: but the same which all men employ, from the cradle to the grave, in forming correct conclusions.

(*Charles Kingsley in* "Health and Education.")

The work of Drayson entitled *The Earth's past History* being out of print and difficult to procure, the writer of the pamphlet *Why we may expect warmer winters* has compiled the following explanation of the theory involved, quoting extensively from the work in question so as to explain as clearly as possible what the discovery was, how it carried with it its own confirmatory proofs, and why it has not been favourably received in the astronomical world.

It does not require an expert knowledge of astronomy to adjudicate on facts partaking of the nature of circumstantial evidence such as might be placed confidently before any jury, in expectation of a decision in accord with common sense; but as a preliminary guide to the matter in dispute, it is considered advisable to explain by a simple illustration what the terms "Precession of the Equinoxes," "Obliquity of the Ecliptic," &c., on which so much depends, really are.

Firstly, let the reader imagine the earth to be represented by a sphere of any material, light enough to float just half immersed in water, and let the water surface represent the "plane of the ecliptic." The sphere may be supposed to have a stick passed through its north and south pole to represent the imaginary line of direction of the "pole of the heavens," as it is called, and if this stick is pulled out of the perpendicular to the extent of an angle of 23° odd, the inclined (oblique) position of the sphere to the water surface represents the "obliquity of the ecliptic." (*See Frontispiece.*

The points where the equator of the sphere cuts the water surface are called the equinoctial points, and during the earth's annual orbit the sun is on two occasions at the zenith of these points, causing the equinoxes.

If there was no movement of the pole of the heavens, the equinoxes would occur annually exactly at the same times of the year, but there is a small movement, which makes them occur each succeeding year a little in advance of the due time, and this causes the "precession of the

equinoxes." This movement is circular, taking many thousands of years to complete, and can be fairly represented by the stick (the pole of the heavens) being moved round in a circle parallel to the water surface, while keeping its oblique position. According to astronomers a complete revolution is made in 25,868 years, and is said to take place round the pole of the ecliptic as a centre.

Drayson's contention, it may be here remarked, is that this last statement is erroneous. He shows that the pole of the ecliptic is not the centre, but that another point is. An important result is thereby obtained ; in that, with Drayson's centre, the obliquity will vary sufficiently to cause an Ice Age, whereas with the hitherto supposed centre of the movement, no reason for any change of climate due to astronomical causes can be postulated.

When this supposed conical movement of the axis symmetrically to the pole of the ecliptic was accepted as complete and satisfactory, it was not known that there was any variation in the obliquity of the ecliptic ; and since the angular distance of the pole of the heavens from the pole of the ecliptic is the exact measure of the obliquity, and as this obliquity was assumed to be invariable, it was therefore asserted that the earth's axis traced a conical movement round the pole of the ecliptic *as a centre*.

More accurate instruments and more careful observers proved that the obliquity was not invariable (though it will be seen that Sir R. Ball, in the work quoted on page 32, attempts to minimise the importance of this), but had decreased during the past 2,000 years at least. It followed, therefore, that the pole of the heavens could not trace a circle round a supposed centre, from which centre it continually decreased its distance.

In order to meet this contradiction, theorists asserted that the pole of the heavens did always move round the pole of the ecliptic as a centre, but that this centre moved so as to accommodate itself to the theory. When these theorists had altered the position of the pole of the ecliptic, it followed that the plane of the ecliptic, 90° from its pole, must also be altered in a corresponding manner, and, consequently, that the latitude of stars must also be altered to agree with this movement. When, however, ancient catalogues of stars were compared with modern catalogues it was found that the latitude of stars had not varied in the manner they ought to have done in order to agree with these theories.

Here was another difficulty, but it was overcome by stating that as the stars were not situated where by theory they ought to have been, therefore the stars themselves must have moved, and every star whose position did not agree with the theory was assigned a proper motion of its own.

Another science, however, now made itself known, namely, Geology, and geologists stated that there was evidence on earth of very great changes of climate in the past history of the earth, far more than could

be accounted for by any local changes of land and water, or by ocean currents, and astronomers were asked for an explanation—as these changes were seasonal and periodic it was as much an astronomical question as was the construction of the calendar—but astronomers could give no explanation. It was stated that the pole of the ecliptic could not vary its position more than 1° 21′, and therefore that the obliquity could not vary more than that amount. That a very slightly different movement of the earth (as demonstrated by Drayson) from that which had been assumed, would account for very great changes of climate, although no movement whatever occurred in the ecliptic, did not seem to occur to anyone.

A singular contradiction, however, still continued to be practised in astronomy. Whilst it was asserted that every movement of the earth was known with such minute accuracy that it could be affirmed that no changes of climate due to the obliquity could have occurred for hundreds of thousands of years, yet perpetual observations were still necessary in order that the position of each star relative to the pole and meridian should be assigned for some five or six years in advance. If the actual movements of the earth were *really* known the position of each star could be calculated for one or 500 years in advance, without any reference to observations.

What would be thought of the knowledge of an astronomer who employed his time in measuring the altitude of the sun every five minutes between 8 a.m. and 9 a.m. in order that he might predict what would be the sun's altitude a few minutes after 9 a.m.? If the daily rotation of the earth were known and its annual revolution round the sun, and the sun's declination for the day, then the sun's altitude for any given latitude can be *calculated* for each hour and minute of the day. The same results as regards the stars can be calculated for hundreds of years when the slightly different movement of the earth's axis, discovered by Drayson, is known and understood.

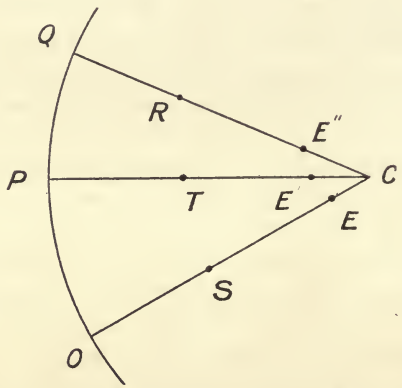
Method of Finding the Obliquity and Pole of the Ecliptic.

In order to find the extent of the Tropics and Arctic Circle, or what is termed the obliquity of the ecliptic, astronomers measure the greatest meridian altitude of the sun at the period of the summer solstice, and its least altitude at the period of the winter solstice. The difference of these two altitudes divided by two is taken as the obliquity of the ecliptic. Whatever this obliquity is, the angular distance between the pole of the heavens and the pole of the ecliptic must, by a geometrical law, be of the same value ; consequently, if the obliquity were 24°, then the angular distance between the pole of the heavens and the pole of the ecliptic would be 24°. If the obliquity were 23° 27′, as now, the angular distance between these poles would be 23° 27′.

From the very earliest date down to the present time observation has proved that the obliquity of the ecliptic has slowly decreased. There is no *visible* point in the heavens to indicate where the pole of the ecliptic is situated, consequently the position of the pole has been assumed from time to time in the following manner :—

Since it was assumed that the pole of the heavens traced a circle round the pole of the ecliptic *as a centre*, when it was found that the pole of the daily rotation did not vary its angular distance from a star, it was assumed that the pole of the ecliptic must be on the arc of this star and distant from the pole of the heavens as many degrees and minutes as the obliquity was found to be at that date.

As the pole of daily rotation is carried round by the second rotation other stars would be found whose polar distance did not vary. Consequently the pole of the ecliptic was assumed to move from point to point in the heavens and in the manner shown in the following diagram :—



Take OPQ as the course traced by the earth's axis in the sphere of the heavens and due to the second rotation, and C the pole of the second rotation 29° 25′ 47″ from the arc OPQ

When the pole was at O the star S was found not to vary its polar distance, and the pole of the ecliptic was supposed to be on the arc OS, produced and distant from O whatever the obliquity was found to be at that date. Suppose the obliquity was 24°, as it was about the beginning of the Christian Era, then E, the pole of the ecliptic, would be assumed to be at E on the arc OC, and 24° from O.

As the pole of the heavens was carried round to P by the second rotation, and a star T was found not to vary its polar distance, the pole of the ecliptic would be assumed to be on the arc PTC, and distant from P an angular distance equal to the obliquity at that date. Taking the obliquity at 23° 40′, as it was found to be about a thousand years ago, then the pole would be assumed to be at E′ 23° 40′ removed from P.

In like manner the pole of the ecliptic would be assumed to be at E″

23° 28′ from Q when the pole of the heavens was at Q and the obliquity 23° 28′. Hence it has been assumed that the pole of the ecliptic has a movement laterally, and at the same time towards the pole of the heavens in order to account for the decrease in obliquity or angular distance of these two poles, whereas there is not the slightest evidence to prove that any such movement occurs in the pole of the ecliptic.

The results of this assumption are most serious, many details in astronomy requiring perpetual correction ; such, for example, as inserting a few minutes of purely imaginary time between the end of one year and the beginning of the next in order to make facts and theory agree ; this was the case in 1833-34, as is mentioned in the last note of Sir J Herschel's *Outlines of Astronomy.*

Further, and in consequence of these assumptions, an entire revolution of the equinoxes is stated by astronomers to be completed in 25,868 years. The true measure of this period is the time during which Drayson states that one second rotation occurs, occupying 31,682 years.* How is this figure of 25,868 arrived at ? When the obliquity was 23° 28′ in amount, the annual rate of precession was found to be 50″.1. Then by rule of three, if 50″.1 was the amount of precession in one year, it was assumed that to cover 360° would occupy 25,868 years. This figure has been constantly given in text books by writer after writer, in spite of the fact that it is known that at the beginning of the Christian Era the obliquity was 24°, which would give a different value for the duration of the cycle.

What has been already said will serve to show firstly that the assertion that the pole of the ecliptic was the centre of this movement was a mere assumption ; secondly, that it was also assumed that the pole of the ecliptic had moved, when it was discovered that it did not remain the centre ; and, thirdly, a final assumption was involved, by which it was deemed that the stars had " proper motion." In addition, in spite of the fact that the changing obliquity can be shown by observation not to be at a uniform rate, the annual rate of precession has until quite lately been supposed to have been a constant, 50″.1 per annum, for which a period of 25,868 years is stated to be required for an entire revolution of the equinoxes.

This confusion, and consequent adjustment and readjustment of figures with the contradictory statements put forward from time to time regarding the period of one entire revolution, indicates that there is something wrong. Drayson shows how simple the cause is, though obscured by the coincidence that just during the centuries when most of our astronomical knowledge has been gained it happens that the real movement of the pole is very nearly identical with the supposed movement. Had observations been made as closely 5,000 years ago the real motion would most certainly have been discovered. If the diagram is

* Since found by de Horsey more accurately to be 31,756.

considered it will be noticed how routine and preconceived ideas are apt to blind one to realities, and how near astronomers have been to this important discovery. In assuming the pole of the ecliptic to be at a certain spot at one period and in other positions at other periods, if anyone had correlated the positions and produced the arcs beyond the ecliptic poles, they would have been found to meet at one point C, and thus the whole matter of the second rotation would have been revealed !

Drayson goes on to say " Routine, however, won the day, and the theory that the pole of the heavens always traced a circle round the pole of the ecliptic as a centre remained accepted as a fact. Then it was supposed that by employing more observers and building additional observatories, a solution might be found of these mysteries which were actually self-created."

Improbable though it may seem that so important a fact escaped notice, such appears to have been the case, because Drayson with his wizard-wand of precise knowledge proves that he can solve any question regarding polar distances of stars, the obliquity of the ecliptic at various dates, &c., &c., and gives a confident and definite answer to the riddle of the Ice Age, fully explaining the cause thereof, the dates of waxing and waning, and the time of greatest intensity ; whereas orthodox astronomy can only direct enquirers to seek for a cause elsewhere, as the movement of the pole of the heavens is said to preclude all possibility of a general change of climate being directly due to it.

It would be in place here to quote General Drayson's challenge to Astronomers in the Preface to *The Earth's Past History*.

" Nothing in the form of a theory or probability is submitted for an opinion. In the following pages rigid facts are dealt with and sound geometrical and mathematical proofs are given to verify every statement that is made. For a person acquainted with geometry to invite the opinion of ' an authority ' as to the truth or falsity of the assertions that two sides of a plane triangle are greater than a third side ; or to invite this authority to express his views as to whether the centre of a circle always maintained a uniform distance from the circumference would be as absurd as to enquire whether two added to two amounted to four. There are certain facts and certain proofs which are beyond question, and are independent of mere opinions. . . . . The number of absolute proofs that exist of this second rotation, the exact calculations that can be made when a knowledge of it has been gained, and the simple explanation it gives not only of astronomical, but of geological facts, places it before the enquirer, not as a speculation or theory, but as a mechanical movement fully demonstrated."

" The reader of this book, who will take the trouble thoroughly to understand the second rotation of the earth, will be able to accomplish by calculation more than the astronomers of the whole world have been able to arrive at by perpetual observations during the past 200 years.

"This is no mere assertion. I give my proofs and calculations, and show how these results are obtained ; any other person can, when he is acquainted with the second rotation, do the same. I submit a challenge and I state that I can find the exact polar distance of a star for fifty years in advance or in the past from one correct observation of this star, and in this work I prove I can do so, not by one example only, but by several.* . . . .

"I challenge any astronomer to *calculate* what the obliquity of the ecliptic was 5,000 or even 500 years in the past, or what it will be 1,000 years in the future. To adopt the present mere fudge rule of substracting from year to year a given value from the obliquity found by observation is not a calculation, and what is more, it is unsound geometrically, and has to be corrected from time to time. . . . . The proof that the above statements are rigidly correct are given in this book."

THE ASTRONOMICAL POSITION.

When one hears that the above challenge was made nearly forty years ago, and that no official notice has been taken of the matter, one would naturally conclude that the book in question, with the proofs therein contained of the different problems resolved by his theory, was an elaborately printed record of an entire hallucination on the part of a man, otherwise able, but with a bee in his bonnet. One would also imagine that the theories attacked as unsound were as well established and unassailable as that of the cause of night succeeding day, and therefore that this self-styled discoverer must be relegated to the ranks of the flat-earth enthusiasts and their kind, without more ado. But what are the real facts ? They are these :—

Firstly, that astronomy, when it did endorse the opinion of Croll, testified to conditions of extreme cold as affecting the Arctic and Antarctic *alternately*. We know now that this is not true, but Drayson alone was able to interpret the facts rightly, and to state that the periods of cold were contemporaneous at both poles. The confident way in which the above official opinion was asserted will be more appreciated if the quotation on page 15 is continued. The continuation runs thus :—

"*Of course there is no chance of such a contingency arising, and I merely annunciate it to show the significance of the doctrine that the ice ages*

* Compare a computation by Mr. H. P. Hollis, of the R.A. and N.P.D. of Alpha Draconis for 1755 from its co-ordinates in 1900 given in the "English Mechanic," 23rd May, 1912. It will be seen that whereas this method requires the observed co-ordinates of this star on at least three dates separated by wide intervals, Drayson's method can arrive at the same result from one set of co-ordinates and certain fundamental data equally applicable to all stars.

Favourable as this is for Drayson, it does not state the whole case, which is that Drayson if living in 1755 could have predicted the position of Alpha Draconis in 1900, while his contemporaries would have had to "wait and see."

in the opposite hemispheres were not concurrent, but were consecutive ; in fact, we may feel convinced on astronomical grounds that this must have been the actual state of things."

Secondly, that the theory of practically unchanging obliquity cannot be maintained nor explained on any proved grounds. The attempt to do so is the cause of the muddle exposed on pages 32 and 33. See also page 63, Part III, where it is shown that the movement of the ecliptic plane cannot account for any observed decrease. This will be found to undermine the last stronghold of orthodox astronomy.

Some Authoritative Opinions of the Drayson Theory.

From the four following extracts from criticisms of the Drayson theory it will be seen that the dogma of the cause of the precessional movement alone stands in the way of its acceptance :—

(1) " The movement of the earth's pole is assignable to two well-recognised physical causes—precession and the action of the planets (gravitation). Drayson rejects both these, and substitutes a mere piece of calculation without any physical basis."

(2) " General Drayson was, I believe, a distinguished officer, but his knowledge of astronomy was not very great, and the ideas he entertained cannot be put in serious comparison with the results that have been obtained by the great mathematical astronomers, Newton, Laplace and a host of others to whom we owe our knowledge of the movements of the solar system. The inclination of the ecliptic in 13544 B.C. could only have been as great as Drayson and Marriott say, if we are content to throw overboard the law of gravitation, and accept a statement for which no proof has been adduced."

(3) " The official explanation of precession is based on two assumptions : (*a*) That the earth is not a sphere, but has an equatorial protuberance ; (*b*) That the law of gravity is true. Given these two, the rest follows by pure logic."

(4) " Drayson was not by any means what is generally known as a paradoxer or crank. . . . Now it may be thought—General Drayson thought so—that a geometrical formula, which fits a series of observations so well, must be accepted. But there is another geometrical formula, namely, the formula of precession of the text books, and the question arises, which should be chosen ? Drayson's is geometry and nothing else. The precession formula is based on a dynamical reason—it is the result of the rotational movement of the earth and the attraction of the planets, so that a *cause* can be assigned for the observed facts ; but for a polar movement about a centre 6° from the pole of the ecliptic no adequate reason can be given."

Drayson did not know, and had never pretended to give, a reason for the annual motion of the pole, unless it be that this second rotation is caused similarly to the second rotation which may be observed in a gyroscope. We do not know the cause of the earth's *daily* rotation, but we can prove it, as we can its annual motion round the sun. Similarly it appears sufficient proof of this annual motion of the pole to show that it precisely accounts for all the apparent variations (or so-called precessions*) in the positions of stars, whereas without such annual motion the stars would never appear to vary their position in right ascension or declination.

History of the Precession Position.

It is instructive to consider here the history of this Precession-cause idea, which stands in the way, preventing the fact of changes in obliquity of the ecliptic being given their proper significance.

Newton was the first to show that in a body composed of a series of spherical concentric layers, each homogeneous, the attraction of the body itself, and of other attractive centres on the body, might be considered to act through the centre of the body. If then the earth were a perfect sphere, it is obvious that the attraction of the sun, moon and planets would be powerless to affect its rotation, for, as the attraction of each would act through its centre, the moment of these forces about the axis would be *nil*.

If, on closer investigation, we improve upon this first estimate of the earth's figure and call it an ellipsoid, the attraction of the moon, and, in a minor degree, of the sun and planets, can be shown to cause the earth's axis to perform a slow movement describing a double cone with its base said to be parallel to the plane of the ecliptic, which movement causes the precession of the equinoxes, as before explained on page 41. This movement seemed at first to fit in so well with the observed shift of the pole of the heavens that it was accepted unanimously, more especially as its explanation agreed well with the assumption that the earth was an ellipsoid. But it was found that the movement of precession was not the constant it had been supposed to be ; hence the explanation that the pole of the ecliptic itself was moving.

In more recent years, while more accurate values for annual precession have been obtained, proving it to be not a fixed but variable quantity, so also more accurate ideas of the figure of the earth have been formed, and we now know that the earth is not the simple ellipsoid

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* Much confusion has been caused by the change of late years of the term annual "variation" to annual "precession" of stars."

The annual precession of the equinoxes and the apparent (so called) precession of stars are both caused by the annual motion of the pole of the earth and the obliquity of the ecliptic, and not by the attraction of gravitation of the planets.

The precession of the equinoxes, except for a minute correction, is a function of the annual motion of the pole and the obliquity of the ecliptic.

The annual apparent "precession" of stars is solely caused by the annual motion of the pole on a circle distant about 29° 25′ 47″ from the centre of second rotation. *(de Horsey.)*

it was formerly supposed to be. Pendulum experiments made all over the world show further an unsuspected lack of true symmetry in its conformation. With the gyroscope analogy above mentioned, this asymmetry seems a natural corollary, so to speak, of the second rotation. Text books wedded to text books in the close bonds of tradition have failed to appreciate the changes which time has wrought, and the importance of these modern researches, from an astronomical point of view.

It is curious that there has been advanced no opposing argument of any real mathematical value. The novelty of the idea, and its subversive influence on theories supposed from their venerable age to be true, seems at present to bar all discussion.

To say that it is contrary to ideas which were held by Newton and astronomers of his time and subsequently, stamps it merely as heretical to opinions formed in the early days of the science. Progress in our knowledge must come, and has come even in our time from quite unexpected sources. As photography and the spectrum have shed new light on astronomy it would be quite natural if the science of geology were to cause to be illuminated a hitherto obscure movement of the earth's axis. It has therefore been rather hastily assumed that it must necessarily be unsound. Because the movement of the pole of the heavens was declared by Newton to be caused by the pull of the sun and moon on the equatorial protuberance, therefore the centre of this movement cannot be eccentric to the ecliptic pole ; and seemingly any suggestion to the contrary puts in question the laws of gravity, and is almost sacrilegious.

Will this bear examination ? It is the one and only obstacle to the complete vindication of Drayson's theory. Can anyone prove the Newtonian contention without assumptions not justified by facts ?

In the face of the multiple proofs of the correctness of the Drayson solution as applicable to nearly all the problems connected with the celestial movements, no mere denunciation is sufficient. Against so many convincing proofs there must be put forward no unwarranted assumptions. Nothing but the severest tests of verity can be accepted. Let us examine the thesis a little more closely.

Now the Newtonian position of affairs postulated the earth as a homogeneous symmetrical ellipsoid with an accumulation of matter round its equator symmetrically placed, which belt of matter is acted on by the attraction of the sun and moon and planets. Since Newton's days this condition of things has been more closely defined, and it has been stated that for all practical purposes the sun's influence, like that of the planets, may be neglected.

The attraction of the moon in its periodic movements produces another effect on the earth, that of "Nutation,"* a very small movement

* From a gyroscopic point of view, the effect of the moon in thus deflecting the axis 9 seconds out of the normal seems about as much as can be expected with a gyroscope of such enormous mass, as is the earth. The precession movement may eventually prove to be the effect of tidal friction, if not to be ascribed to initial conditions beyond our ken.

compared with the Equinoctial Precession ; still, it is distinctly traceable to the moon. Hence the same body, the moon, produces a small effect in one direction which is not uniform, and a large effect in another direction which is constant and uniform. This does not seem a satisfactory statement.* Further, more accurate measurements have determined a lack of equality in the equatorial diameters ; the equatorial circumference is not a circle, but slightly elliptical. Modern soundings of the oceans have established an enormous disparity between the depths of the water-areas as compared with the elevation of the land-areas,associated with a want of uniformity of distribution which must have a vastly greater effect on the gravitation-pull of the moon than any symmetrical equatorial protuberance could possibly have.

Of late years also geodesical measurements have given rise to an opinion (Jean's theory), though it is not authoritatively accepted, that the earth has a *tendency* to a pear shape, England being near its blunt end, and the "stalk" end being in the Pacific. Though this matter has not yet been thoroughly investigated, the necessary perfection and symmetry of figure for the Newtonian theory evidently does not exist.

Had it been the desire of astronomy to in any way invalidate Newton's reasoning for the precessional cause, all the above facts and many others would have been set in array as absolutely destructive of his theory.

The Analogy of the Discovery of the Daily Rotation.

It is interesting to study the arguments formerly used against the daily rotation of the earth some 300 years ago. It will be seen how analogous these are to the objections raised in general against the present theory. They were these :—

Every fact connected with the rising and setting of the various celestial bodies is fully and clearly explained by a stationary earth and a revolving heavens each day.

During 1,400 years the able astronomers of every country have agreed that the earth is stationary, and that the heavens revolve daily. Is it even possible that all these men were wrong ?

Eclipses have been predicted with great accuracy during the 1,400 years on the theory of a fixed earth. This would be impossible if the theory were wrong. You must prove to us, they said, that the earth rotates before we give up our convictions of a fixed earth, &c., &c.

So much for the ancient astronomers. Those who followed and overcame their prejudices, made enquiry, and found the revolution of the earth explained a multitude of facts, which facts had previously required a multitude of theories, to explain them

Drayson claims similar results. The precession, the changes in N. Polar distance and right ascension of stars, the error in standard time,

* Angular velocities, like linear, are subject to the parallelogram law.

the decrease in the obliquity and its rate, the cause of the ice age, its date and duration, its being contemporaneous in both hemispheres, are all explained by one movement of the earth !

RESEARCHES CONFIRMATORY OF DRAYSON'S THEORY.

If the opinions of geologists are sought regarding this matter it will be found that a larger number are inclined to favour a more recent date for the ice age than has been hitherto supposed. American geologists with whom Croll's theory has long since been discredited are many of them quite in favour of the Draysonian *data*, and notably so Professor Wright, the author of a classic and comprehensive work, *The Ice Age in North America*, who has welcomed the facts given in Part I as confirmatory of his own investigations.

Archæologists, moreover, in the study of primeval man are more and more convinced of his existence throughout more than one ice period, and are inclined to substantially reduce the cycle of those periods, bringing them into remarkable accord with the theory of the second rotation. An illustration of this appears in a recent work, *Ancient Hunters*, W. J. Sollas (Macmillan).

Dr. Allen Sturge, whose researches into the flint implements of Suffolk (and especially those which from their scratches are indicative of the passage of ice over them) have made his opinions authoritative, has been able to announce the astonishing fact that neolithic man was in Suffolk previous to the last ice age. He has now declared himself in favour of the Draysonian chronology, as will be seen later.

Fortunately for the theory of Drayson there has arisen a champion well qualified to receive the confidence of the public. *Draysonia** (Longmans), from the pen of Admiral Sir Algernon de Horsey, is an able expression, mathematically and astronomically, of all that Drayson tried to teach, and incidentally bears a still stronger claim to notice in that his first intention in dissecting Drayson's theories was with the sole object of proving them false, which he signally failed to do.

An Extract From "Draysonia."

The direct proof of Drayson's system is obviously difficult to establish, but as in criminal jurisprudence circumstantial evidence is in many cases more reliable, because, unlike a witness, it cannot lie, so in the case of Drayson's system there is the following circumstantial evidence to put forward, evidence which any person of ordinary mathematical

* Published, by a coincideuce, in the same month as the pamphlet "Why we may expect warmer winters."

ability can test for himself. The system enables such persons to ascertain by calculation the following results for any year, present or future, without reference to the *Nautical Almanac* of the year required :—

1. The obliquity of the ecliptic.
2. The right ascension of any fixed star.
3. The declination of any fixed star.
4. The precession of the equinoxes.
5. The right ascension of a star from its apparent annual precession in declination, if known.
6. And conversely, the apparent annual precession in declination from its right ascension,

* * * * The author goes on to say :—I think I may claim that no astronomer, however able, can produce the above results without acceptance of Drayson's theory and data. In confirmation whereof, as I have previously stated, so great and distinguished an astronomer as the late Sir George Airy, whilst admitting the correctness of Drayson's formula, told him that he had tried in vain to discover how he had framed it.

In another part of the same book de Horsey shows that the error in sidereal time asserted by Mr. Stone to be in 1892 41.51 seconds, though the existence of an error was not generally accepted by astronomers, was by Drayson's data shown to be right within a small fraction of a second. This in itself is of extraordinary evidential value.

The Evidence of Flint Implements scored by Ice Agency.

These have a remarkable bearing on the theory. The summary of the various glaciations in Suffolk, indicated both by topographical features and by paleoliths of various horizons and of diverse manufacture and weathering, is that given by Dr. W. Allen Sturge. The locality is especially rich in such relics, and, moreover, the investigator has come to the conclusion that the evidence collected from the flints tallies with and fits into the Drayson theory in a remarkable manner. It is therefore fitting that such, whether open to dispute or not, should be given prominence here.*

The summation of the various glaciations are as follows, given from later times backwards :--

I. A series of at least six and probably more glaciations during the Neolithic period. These glaciations gradually work up to a maximum of severity, and then the intensity of glaciation diminishes until the most recent one is of relatively slight degree. The evidence of the glaciations lies in the very

*It must be noted that these opinions were arrived at by Dr. Allen Sturge wholly independently. He writes :—"I for one had no knowledge of Drayson when I worked my part of it out. I distinctly felt the want of some addition like Drayson before I heard of him, and his work just fitted in like a glove to the hand." . . . "But I feel sure that Drayson is only one of the elements in the glacial problem—one of the most important, it is true, but still only one—and I think this should be clearly brought out."

large numbers of striated flints of fine chalcedonic quality and of Neolithic types found lying on the surface of the ground.

II. A series of four glaciations—or groups of glaciations—described by Professor Penck, of Berlin. Again going backward in time, these are :—

(*a*) The Würmian glaciation placed by Penck in the period immediately following the Mousterian stage of human culture. Penck's attribution is fully borne out by the evidence in Suffolk.

(*b*) The Rissian glaciation placed by Penck somewhere in the period of the later Acheulean stage of human culture. The Suffolk evidence, though less clear on this point, seems to be in accord with Penck.

(*c*) The Mendelian glaciation.

(*d*) The Günzian glaciation.

With the data at his disposal Penck does not seem able to co-ordinate these last two glaciations with any given geological time with any certainty. In England, however, we have many pre-Rissian gravels containing human implements of earlier "drift" types. It may be taken as an assured fact that these gravels are all of glacial origin, and therefore it seems justifiable to refer them in a general way to one or both of the great pre-Rissian glaciations described by Penck.

The detailed study of these gravels is a highly complex one ; but two great groups seem to stand out : (1) a later group represented by the well-known Warren Hill gravels at Mildenhall ; (2) an earlier group comprising the series of gravels in the Thames Valley lying at or about the 100 foot level O.D. We shall probably not be far wrong if were attribute the two great groups to the Mendelian and Günzian respectively.

III. At a still earlier stage of the world's history we come to the great series of vast glaciations represented by the boulder-clays, the mid glacial sands, the cannon-shot gravels and other deposits. These can be clearly shown to be older than any of the implementiferous "drift" gravels above alluded to.

IV. The investigations of Mr. Moir, Mr. Clarke and others, reported in the Philosophical Transactions of the Royal Society by Sir E. Ray Lankester, prove clearly the existence of extensively scratched flints beneath Pliocene deposits. These must have been glaciated before these deposits were laid down, and afford full proof of still earlier glaciations than those of the boulder clays, &c.*

* The rocks bear records of glaciations, at various epochs, *throughout* Geological History.

The subject is a very abstruse one, and is at this stage of research impossible to arrive at a decision, which will not be open to controversy, but in view of the competence of this investigator, his wide experience of the subject, and the really immense mass of evidence collected and categorised by him, the results arrived at are of extreme interest. They are stated here in the hope that they may prove useful hereafter as a rough framework of a more complete history, when Drayson's movement of the pole is accepted.

WEATHER AND CLIMATE CHANGES.

As this is a sequel to the pamphlet forecasting warmer winters, a few recent facts that bear on this subject are here signalised.

Though the winter of 1911-12 had one longish spell of keen frost, no frosts were experienced in the South of England until February. The other months were not only free from ice and snow, but were remarkably warm. In North America the cold spell was very severe, but was preceded by an exceptionally warm Christmas. The cold of February in Europe was very short-lived, and was succeeded by a phenomenally early spring, marked by the break-up of ice in the Neva three weeks before the usual time, a phenomenon which had occurred, it is said, only twice in the preceding century. The retreat of the Alpine glaciers has lately been much accelerated.

The recent loss of the " Titanic " was primarily attributable to an unusual condition in Atlantic waters due to the fact that the ice had broken off from Labrador and Greenland very early and abundantly, so that bergs were in quantities in a latitude where they are less frequently met with, a whole month before their time.

In May it was reported that Stockholm had " warmed up " unusually early with a temperature of 50° at 6 p.m.

The International Bureau of Agriculture held a conference in Rome during the summer of 1911, with special reference to the world's weather, and the following appeared in the *Daily Mail* with reference to it :—

> " Many curious and as yet unrelated facts have appeared in these comparative statistics of the world's weather, driving some students and travellers to the belief that the world's climates are shifting. Professor Mavor, of Toronto University, believes, and backs his opinions by many persuasive figures, that frosts are growing progressively milder in Northern Canada, which agrees with a prevalent view of the climate of Siberia, which, according to one statistician, will be ultimately capable of growing enough corn for the food of the world."

In an article in the *Geographical Journal* of October, 1911, discussing the changes wrought by farming operations in Western Canada, the writer says :—" So much warmer does the soil and immediate layer of air remain through the night, that in Alberta the frosts do not begin to injure the wheat till a full fortnight later than they did a generation ago." Though this was stated to be attributable to the tillage of the soil, the fact is very significant, taken in conjunction with the observations of Professor Mavor, and with the interesting extract which follows, of which the title in the *Daily Mail* of December 25th, 1911, was *A Change in the Climate*, by C. de Lacy Evans.

* * * * *

Zoologically the same change is observed, and it is not long ago since I read a letter from a nephew of Mr. George R. Sims giving a list of birds which formerly inhabited the United States only, but have recently migrated northward, and are now commonly found in Lower Canada. This shows that the northern climate is becoming warmer, and the statement is confirmed by the fact that the records of the Hudson Bay Company state that " the winter on the shores of the bay has grown shorter, at the rate of one day in every ten years." The same change is noticeable in Siberia, Greenland and Alaska.

The northern ice-cap is decreasing in area and thickness, and the land, which was tropical and bore the grape-vine, the magnolia and the water-lily before the Great Ice Age, will become habitable again. As an instance in confirmation of this, in 1907 Dr. W. S. Bruce's expedition explored the whole of Prince Charles Foreland, an island sixty miles long lying to the west of Spitzbergen, where only ice and snow had previously existed, " brilliant verdant vegetation was found in several places."

In a letter to the *East Anglian Times*, Captain E. G. Pretyman, M.P., in discussing *Why we may expect Warmer Winters*, put forward an interesting surmise as to the possible cumulative effect of this change :—

> " This matter has great practical interest as affecting the future conditions under which agriculture will be carried on, and it is important to consider whether the moment of warmest winters will be just at the time of least obliquity. To examine this, suppose we divide the ' Great Year ' of 31,000 years into twelve hypothetical months, each representing about 2,500 years, and let the time of greatest obliquity be December 21st, and of least obliquity June 21st, then on that hypothesis it is now June 16th or 17th of the present ' great year.'
>
> " The June temperature, especially in high latitudes, is much lower than that of July or August, and similar conditions might apply to the ' great year,' and they would be still further accentuated as the ice-caps at the Poles are reduced, and if we assume these to have shrunk to much smaller dimensions in the next 400 years, the cold springs, which are the check to sub-tropical vegetation

in these latitudes, would presumably cease. This might make a return to the sub-tropical conditions, which geology teaches us existed in these latitudes before the last Ice Age, and that the period of least cold would be from 3,000 to 4,000 years ahead of us.

"All this is, of course, largely conjecture, but it is highly interesting, and the whole question raised is worthy of close study and examination in scientific circles."

GEOLOGICAL VIEWS AS REGARDS GLACIAL PERIODS.

In studying what has been written and discovered by geologists in various parts of the world, one is confronted with the difficulty that as there were undoubtedly various glacial epochs differing in intensity some writers fix on the signs of the maximum of glaciation, and speak of such as *The Ice Age*, ignoring the minor glaciations. Others, chiefly students in America, seem inclined to maintain that there was only one and all-predominant glaciation, and therefore periodical glaciations are not proven, whereas English and Continental geologists number the known glaciations as eight and more.

It seems difficult to reconcile these conflicting ideas, and yet modern conditions furnish us with a reason for their existence.

First, we have Greenland at this moment still in the grip of the Ice Age owing to its extremely elevated condition of continent. This is one extreme of the scale of varying conditions ; the other is represented by the greater part of Siberia, where the elevation is so slight that nowhere is there a largish area of more than 500 to 600 feet above the sea, consequently the ordinary indications of glacial periods having passed over it are, in spite of its present arctic temperatures, conspicuously absent. Moreover, this fact in itself would militate against the probability of changes in land level, which other parts of continental areas have undergone in glaciation periods, due to the varying pressure exerted on the pliant crust by masses of ice of a mile and often more in thickness ; and it therefore might well be that Siberia has remained through many Ice Ages without any marked phenomena to indicate them.

Between these two extremes of Greenland and Siberia there must be many conditions of continent which represent intermediate phases leaving traces, as in England, of many glaciations, or as in parts of U.S. America of one so extensive a glaciation that some geologists find it difficult to trace signs of preceding ones.

So far only one factor, that of elevation, has been alluded to, but when one considers the presence of the warm currents, and how a change in land figuration, slight in itself, by deflecting the Gulf Stream, may

exercise an extraordinary effect on conditions of climate of continental areas, one must not be prone to make any sweeping generalisations.

In the British Isles during one cycle of glaciation and complete degelation there might well be local signs of several glaciation periods intervening with more genial periods, simply owing to the deflection of the Gulf Stream, which could be brought about by the blocking of the Irish or English Channel with bergs let loose by a more rapid summer thaw. This shunting of the Gulf Stream away from our shores might produce an increase of glaciation lasting for long periods, and concentrate into one cycle, phenomena, which elsewhere are indicative of a plurality of glacial periods.*

When all these variations of condition may exist in different longitudes, one can better appreciate the diversity of opinion which one finds to prevail regarding the lapse of time since the last glacial epoch. Some who like our own geologists have turned their attention to accumulations in one small portion of the area affected, and to changes in the level of the land, while others confine their researches to the glacial moraines and abandoned shore-lines of the great glacial lakes of North America, would be little likely to be able to square their conclusions ; though in each case they might have arrived at a fairly close approximation to reality as regards the lapse of time since the last glaciation for that particular locality.

The foregoing may help to explain how it is that from geologists all over the world as a body no very definite opinion can be elicited. Working in the dark, as it were, with very obscure records, geologists are fain to cling for guidance to generalisations deduced from other sciences. Cramped as they were until quite recently by physicists between quite inadequate time limits for a life-habitable earth and, on the other hand, constrained by astronomy to regard pre-glacial man as living at least 500,000 years B.C., there is small wonder if the chronology of the rock records received various interpretations. The simplification that will be introduced into astronomical calculations by the acceptance of the Drayson theory will be equally noteworthy and systematic in the geological world.†

The writer considers that in this pamphlet are ample proofs of the Drayson theory, but convincing as they appear to be, it may be still thought that some fundamental fact in astronomy must have been overlooked to account for the views of Drayson being so strongly opposed

* This phase is rendered more probable by the consideration of the fall of sea-level referred to in the Introduction, p. 13. See also the Bathy-Orographical map of *The Survey Atlas of England and Wales* (J. G. Bartholomew).

† Though the Drayson theory is destructive of the main argument put forward by Croll, in justice to the latter it must be said that in all probability the change of ellipticity in the earth's orbit will be found to profoundly affect the severity of the successive glaciations, and to furnish a clue to their diverse character and sequence.

by men technically capable of judging the evidence, but having seen various criticisms of it in the press and in private letters he is fully persuaded that in no single instance is Drayson or de Horsey convicted of error in computation or of unfair juggling with figures ; and that the Newtonian theory of precession furnishes the only difficulty in the way of its complete acceptance.

There is throughout the criticisms directed against the theory a curious inability apparently, to gauge the significance of the power which a knowledge of Drayson's data puts into the hands of anyone, even with only a tyro-knowledge of astronomical questions. For instance, when the writer, using Drayson's data, without any previous acquaintance with obliquity computations, adopted the statement made by Drayson that some 400 years hence the pole of the ecliptic and the pole of his second rotation would be on the same arc, and therefrom accurately found the obliquity for the current year, he was told by an astronomer that *it only proved his arithmetic to be correct.*

This attitude is again illustrated by a criticism of *Draysonia* in *Nature*, of November 16th, 1911, which elicited a reply from Admiral Sir Algernon de Horsey on December 14th, containing the following :—

> " Your reviewer further states that I have computed the ' precessions ' of many stars by Drayson's method, and that if this proves anything it proves the correctness of the *Nautical Almanac*. This is a mistake, and is an inversion of my process. Instead of having, as he stated, calculated the so-called precessions of many stars I have used the precession so accurately given in the *Nautical Almanac* in order to find therefrom the amount of the annual motion of the pole ; and I have shown that the so-called annual precessions of the stars all varying in amount and direction, both in right ascension and declination, are exactly accounted for by one single movement of the pole, about 20″, which produces the apparent precession as obtained by observation and recorded in the *Nautical Almanac*, the accuracy of which I have never impugned."

We see the same misconception of the position in the following by another astronomer :—

> " The movement of the earth's pole is assignable to two well-recognised causes—precession and the action of the planets (gravitation). Drayson rejects both these and substitutes a mere piece of calculation without any physical basis ; and, oddly enough, he attempts to prove the correctness of his work by appealing to the *Nautical Almanac* calculated by those very astronomers whom he accuses of deceiving the public."

Neither Drayson nor de Horsey implied anything so foolish, and Drayson in particular laid stress on the extraordinary accuracy of astronomical computation, in spite of the difficulties of working with an elusive movement of the pole.

Drayson has more than once been called a paradoxer. What greater paradox than a fixed circle with a shifting centre? A paradox of astronomy which induced him to devote a quarter of a century to its real explanation.

Again the efforts of de Horsey to expound Drayson are termed "pathetic,"* which conveys a suggestion of Hanwell. He might well have sounded a more triumphant note instead of the sober summary given in *Draysonia*, an extract from which is a fitting close, at the present stage, of the whole argument. After stating the fundamental facts of the Drayson theory he writes:—

> "If orthodox authority had alone been listened to we should still have to admit that the earth was stationary, and that the heavenly bodies revolved round the earth as a centre. I am not foolish enough to say of my very limited knowledge that Drayson's system is absolutely exact, but I do say that it appears to afford an easy means of calculating the obliquity of the ecliptic, the precession of the equinoxes, and the right ascension and declination of stars with preciseness for hundreds of years past or future, and that it provides a standard basis of time which will not as at present be always accumulating error. Can orthodox astronomers do any one of these things? Can it be claimed that the present system is correct, seeing that 3′ 3″.68 of *purely imaginary time* were added in 1834, that Professor Stone finds a fresh accumulation of error by 41″.51 up to 1892, and that the best astronomers admitted the whole subject having fallen into confusion? General Drayson's system may be right or it may be wrong, but its results have shown ample cause for its careful and unprejudiced examination. If such examination should be accorded, and the results I have mentioned be shown to be correctly obtained, and further, if with our present knowledge such results can be obtained by no other known method, surely this alone would go far to prove the correctness of his system. * * * * *
>
> "For every great advance in opposition to scientific authorities there must be a martyr; in former times this martyr was tortured or burned. In modern times he is ridiculed, contradicted, or ignored, then years after his death is given a statue. I am inclined to believe with the late Sir John Cowell, and as a promising young officer of the Royal Engineers wrote to me some time ago, that within a generation, although probably not in Drayson's lifetime, his system will be the accepted one of the text-books."

June, 1912.

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* The article from the reviewer of November 16th in *Nature*, in which the expression occurs, failed to point out any single error in the description of Drayson's theory or in the calculations made in *Draysonia*, and after founding his criticisms on two perversions of fact, he termed the efforts of the author as pathetic, saying he had nothing to recommend him for the task, that he had only succeeded in darkening the issue, and that he was scarcely fitted for the work he had undertaken.

Part III.

A DISCUSSION

OF THE

INVARIABLE PLANE

AND OF

THE CAUSE AND EFFECT

OF CLIMATIC CHANGES

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THE INVARIABLE PLANE.

The paradoxes of the Ether are quite equalled by some of the paradoxes of Astronomy, but these latter are defended with such a show of learning and clothed in terms of such terminological profundity that the mere layman is effectually silenced.—(Anonymous writer.)

THE diminishing obliquity is thus recognised by astronomers; "the place of the ecliptic in the heavens is not absolutely constant. The ecliptic in fact is inclined 1½ degrees to the invariable plane, and this inclination is undergoing a slow process of change." The invariable plane is, however, only a mathematical expression of a mean plane for the sun and all the planets, about which they are said to oscillate through long periods of time. This movement is not, however, the result of observation, but of mathematical induction to ensure the ultimate stability of the whole system The *Encyclopædia Britannica*, from which the above quotation is made, hence draws the conclusion that "the diminution of the obliquity of the ecliptic arises only from the displacement of the ecliptic itself."

The examination of this hypothesis in its origin and in its bearing on the traditional attitude of astronomy in such matters is instructive. The "invariable plane" bogey has been directly instrumental in debarring geologists from any further attempts to obtain an astronomical solution of their difficulties, while it has served the purpose in astronomy of hall-marking as an ascertained fact a circumstance which, it is deemed, explains the mysterious decrease in the obliquity.

That the invariable plane is a pure assumption, and that it would not explain the obliquity decrease if it were true, will be shown to be the outcome of a closer investigation into the facts.

The demand of some early geologists for an explanation of the manifest glacial conditions of past times was the *fons et origo* of the enquiry, which was instituted in the early part of the last century, and of which the invariable plane was the invention. This matter, instead of being entrusted to a consultative committee of astronomers, was confided solely to M. Laplace, an eminent French astronomer and mathematician, who had made a profound study of the invariability of the planetary orbits.

Geology at that time was in its infancy.* Some of its convictions were regarded as mere guesses, which so long as they did not interfere with the conclusions of other sciences might be held as pious opinions. Thus, when geologists approached astronomy for an explanation of the Glacial Epoch, it was not felt to be incumbent on astronomers to attach any great importance to the question, nor to find a cause ; but still it was probably considered politic to provide an answer.

From the general tenour of the investigation it is apparent that prominence was given to the fact that conditions of greater obliquity might have caused glaciation, because the result of the enquiry was expressed, so to speak, in terms of the obliquity, but it is noteworthy that instead of proceeding to find the exact path of the pole of the heavens, which would have led Laplace to the discovery of the true centre, and hence to that of the second rotation, he adopted another course solely because he would not and could not get away from the assumption that the pole of the ecliptic was the centre of the curve described by the pole of the heavens.

The observed decrease in obliquity being regarded as a variation, had not then quite the significance it has since attained, so it seemed good to the investigator to find some reason for this in a movement of the earth's orbit.

By what means he arrived at his conclusion is not extant, but he stated authoritatively that the plane of the earth's orbit, the ecliptic, could only move through an angle of 1° 21′ on each side of an invariable plane or mean position, and that therefore the obliquity of the ecliptic could only vary to that amount. What the mean position was, and what particular phase the ecliptic now occupied, it was not thought necessary to mention.

The above extraordinary assertion regarding the obliquity seems only framed on the principle that "*any stick is good enough, etc.,*" the chief motive seemingly being to meet an enquiry regarding a matter for which astronomy felt little concern and no responsibility.

It is important to fully understand the wrong reasoning of the statement that whereas 1° 21′ was the limit of change in the orbital plane, a like angle was the limit of possible change of the obliquity in either direction.

Drayson writes in *Untrodden Ground in Astronomy and Geology*—

> "That a change of 1° 21′ in the position of the pole of the ecliptic should cause a change in the obliquity, it must follow as a geometrical law that the pole of the ecliptic must either move away from or come nearer to the pole of the heavens by 1° 21′, because the distance between the pole of the ecliptic and the pole of the heavens is the exact measure of the obliquity.

* Playfair in 1802 was the first to recognise the evidence of a glacial period having occurred The check received from the inability of astronomers to throw any light on this, delayed progress for many years. The Ice Age first received recognition by the R.G. Society in 1840.

" In order that this decrease should follow as a matter of course a change in the position of the pole of the ecliptic to that amount, the pole of the heavens must trace a circle round *some centre* from which the pole of the ecliptic varies its distance 1° 21′."

But when astronomers at the same time aver that the pole of the ecliptic is the centre of the circle made by the pole of the heavens we come to an absolute *impasse*, since " no variation whatever in the position of the centre could cause a variation in the distance of the circumference from the centre."

But is there any certainty that the plane of the ecliptic has any movement at all ? Doubt is thrown on this investigation at the very outset by the fact that some years afterwards the astronomer Leverrier undertook a similar calculation, and announced that 4° 52′, not 1° 21′ was the limit of movement about an invariable plane.

Whether it is 1° 21′, 4° 52′, or nothing, is really immaterial to the question at issue, because to assert that no change in the obliquity or in the extent of the Arctic circles can occur, except in consequence of a change in the plane of the earth's orbit round the sun, ignores the analogy of the other planets, which will be dealt with later, and is not true in geometry.

The laws of geometry teach that the extension of the Arctic circles and tropics on a planet are dependent on the angle which the axis of daily rotation of that planet makes with the plane of its orbit ; that if, for any cause, say a slight alteration in the position of the centre of gravity of the planet, the axis of the planet altered the angle which it made with its orbit, then there would be a variation in the extent of the Arctic circle and tropics. The movement of the planet itself, not of the plane of its orbit, appears the important question.

One must come to the conclusion that the cause of this topsy-turvy reasoning is directly traceable to the fact that the investigator had perforce to accept the theory that the pole of the heavens traced a circle round the pole of the ecliptic as a centre. Nothing had been observed at that time to throw grave doubts on this erroneous statement, and the fact that no change whatever could occur in the obliquity, if the above were true, was simply overlooked.*

That it was an oversight is the only solution of the muddle, and it is instructive as showing what power of illusion foregone conclusions can exert.

This is believed to be the true inwardness of the " invariable plane " which caused the discomfiture of the geologists, and threw them back on their own unaided resources ; while it furnished a *shibboleth* the more acceptable perhaps, because of its indefiniteness, for otherwise mysterious changes in the obliquity.

* That is to say—putting it popularly—that whatever happens to the Ecliptic it would no more alter the obliquity than " looping the loop " would alter the relative distance between two points in the rigid parts of Pegoud's aeroplane.

One cannot light-heartedly expose this error nor without great hesitation, but there seems to be no doubt that the geometry of these questions has been neglected. The criticism quoted on page 48, the one most fair to Drayson, says : " Drayson's is geometry and nothing else," which gives an entirely wrong impression of the place geometry occupies in science. Its results are more certain and of more positive value than those of mathematics ; it is as if one were to say "Shakespeare's works are stage-plays and nothing else," or that " the discovery of America was navigation and nothing else." Geometry is not to be classed with necromancy or astrology, but is the bed-rock of all reasoning and the embodiment of practical mathematics, and its laws are beyond discussion. It is the very neglect of geometry which has caused all these difficulties.

That the position occupied by astronomy in this matter is no longer considered quite so secure, appears from the following, taken out of the same Encyclopædia of date 1906, under the heading of " Ecliptic " :—

> " Attempts have been made by Laplace and his successors to fix certain limits within which the obliquity of the ecliptic shall always be confined. The results thus derived are, however, based on imperfect formulæ. When the problem is considered in a rigorous form, it is found that no absolute limits can be set. It can, however, be shown that the obliquity cannot vary more than two or three degrees within a million years of our epoch."

This last statement is easily made and is without any proof, but even if this undefined elusive movement of the plane of the ecliptic has any real existence, it can in no way play any part in the diminution of the obliquity.

The Analogy of the Planets.

When one considers the bearing of the question just discussed, if the geometrical reasoning is correct—and when divested of its mystery and brought down to a common-sense level it certainly appears so—then all the results of the sustained effort of astronomy to explain the undoubted decrease in obliquity must collapse like a house of cards. The decrease becomes inexplicable except by the abandonment of the pole of the ecliptic as the centre, and the oracular statement that it is the centre, unsupported by the " invariable plane " reasoning stands revealed as a geometrical absurdity.

The same thing has happened as in the case of the multiple paradoxes of the Ether. Assumption has followed on assumption as if it were a fact, so that the initial theory has got tied into a Gordian knot, for which there is only one method of loosening. Side by side with the false assumption of practically fixed obliquity has arisen a recent theory for the cause of the planetary obliquities, which states that " the rotation of the planets was originally retrograde, and that the attraction of the

sun has a tendency to turn the axis of rotation through 180 degrees; thus, the varying obliquities of the planets indicate different stages in this process." The logical result of this is to destroy the former theory that the change of obliquity is only due to oscillations of the plane of the ecliptic.

This last theory may of course be repudiated, but if we accept, but only for the sake of argument, the orthodox statement that "no change can be admitted to take place in the obliquity of the earth's axis that is not due to a change in the position of the earth's orbit round the sun," we arrive at an important conclusion regarding the *cause* of the obliquities of the planets, which happens to be in conformity with the inference that one would naturally draw from independent considerations.

In the solar system we have various planets, some with satellites and some without, but with the marked characteristics of revolving, all of them, in the same direction, and in approximately the same orbital plane. Presumably therefore they have a common origin, and possess the same specific constitution. When we enquire into the conditions of obliquity of their axes we find them ranging through all angles from 3° of Jupiter to the 80° of Uranus. If we assume, as astronomy has done in the case of the earth, that their obliquities are fixed for all time, and can only vary a few degrees about the invariable plane, we must conclude that these obliquities are inherent, induced not by extraneous forces, but by the position of the centre of gravity in each planet. Therefore the present obliquity of the earth is due to the position of its centre of gravity. Hence we arrive at the important conclusion that the centre of gravity of the earth cannot be the centre of figure; and this, moreover, is in accord with the result of recent pendulum experiments.

It does not, however, directly follow that the behaviour of such a body *in space* will be in conformity with common experience on the earth's surface. One can only surmise that such eccentricity would cause the axis to depart from the position of verticality to the orbital plane.

If we take an extreme case of a planetary body shaped like a peg-top or plover's egg, it is scarcely conceivable that its axis of rotation could be normal to the orbital plane. Therefore it may be assumed that the various obliquities of the planets, or their poise in space, are due to the positions of the centre of gravity in each.

This is so far the only assumption that in this book has been made; and it cannot be contested on orthodox grounds. Further, the conditions of the other planets do not in any way suggest that their obliquities are due to *external* forces. Uranus has four satellites and a very great angle of obliquity. Jupiter has many satellites and practically no tilting angle. Mars has an obliquity greater than that of the Earth, while it only possesses two insignificant satellites of some 10 miles in diameter.

These obliquities entail great differences of climates, together with great variableness between the seasons. Jupiter however has no seasons to speak of, and should possess a uniform climate, with sub-tropical conditions round the poles. Uranus has a winter in duration outlasting forty earth-winters, and from its great obliquity, if possessing an atmosphere, cannot fail to be in the grip of a glacial epoch. Venus is believed to be also in a condition of great obliquity, and if so the quick alternations of intense cold and heat must produce a climate that is unthinkable.* Mars is by far the most interesting planet to us, because we know that it has an atmosphere and ice-caps denoting aqueous vapour. There is some conflicting opinion about its obliquity, but the 28° stated by Drayson is probably correct ; it is certainly not less than this. It is remarkable that when our planet was at this angle we were just emerging from an ice age, so that we dimly discern the possibility that the channels may be the work of intelligent beings, who by colossal engineering have been thus able to maintain the life-giving activities on its surface. Every year new evidence in favour of the artificial nature of these channels is obtained. The ice-caps while they melt away can be seen to darken the channels of irrigation as if a dry soil was being reclothed with verdure. To Martians, perhaps, the passing away of their Glacial Period would be as fatal as, to us, would be the return of such conditions.

While the angle which the axis of daily rotation of each planet makes with the plane of its orbit varies in every conceivable manner, it is remarkable that the planes of these orbits differ only a few degrees from each other. It would, therefore, seem absurd to state in their case, as has been stated in that of the Earth, that no change could take place in their obliquities except what is brought about by the slight movement of each orbital plane with reference to an " invariable plane." It thus seems evident that the position of a planet's axis is due to its centre of gravity and not to small changes which occur in the planet's course round the sun.

This has an important bearing on the objections raised by critics on page 48. The whole question seems to rest on there being a stated physical cause for the orthodox idea, whereas no cause has been stated to exist to account for Drayson's idea ; but to accept Drayson does not involve the jettisoning of the Laws of Gravity as one very high authority so crushingly puts it. It is mathematically sufficient in order to depose the ecliptic pole from its central position, if it can be shown that the Earth is not a symmetrical ellipsoid, *i.e.*, that its centre of gravity does not correspond with its centre of supposed figure, and this has been practically demonstrated by experiment.

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* Some astronomers, however, think that Venus has no axial rotation.

THE VIEWS OF AMERICAN GEOLOGISTS.

The combined effect of all this evidence from so many different sources is irresistible. Large areas in Europe and North America, which are now principal centres of civilization, were buried under glacial ice thousands of feet thick, while the civilization of Babylonia was in its heyday. The glib manner in which many writers, as well as many observers of limited range, speak of the Glacial Epoch as far distant in geological time, is due to ignorance of facts which would seem to be so clear, that he who runs must read them.—Professor G. F. Wright, in "*Origin and Antiquity of Man.*"

Some extracts from the above book will be here given. The phenomena which in North America have furnished evidence regarding the close of the last glacial period have been already alluded to as regards the retrogression of the Niagara and the St. Anthony, but many other phenomena are usefully investigated, which have served to check these estimates. These are here tabulated with the amount in time of the several estimates calculated back to the set-in of the thaw on the termination of the last glaciation period.

(1) The recession of post glacial waterfalls:	
River Niagara 7,000 to 9,000 years.	(Niagara). "No geological conditions could be more uniform and calculated to yield more definite results to careful study."
River St. Anthony 7,000 years.	(St. Anthony). "The post-glacial gorge below the falls requires only 7,000 years for its erosion by the forces which are known to have been in action during the past 200 years."
(2) The enlargement of post-glacial river valleys:	
Racoon Creek, Ohio, 12,500 years.	"but the date of the withdrawal of the ice from Northern Ohio is considerably earlier than that of its withdrawal from Central New York, which marked the beginning of the erosion of the Niagara gorge."
(3). The filling up of post-glacial lakes, etc., "kettle holes," in Andover, Massachusetts — 12,500 (?) years.	"A calculation will show that the total amount deposited in the bottom of this kettle hole by wind, water, and vegetable growth is equal to only eight feet in

thickness over the present bottom. * * * We thus allow 125 years for the accumulation of one inch of sediment, which is about as far as credulity can go."

A post-glacial lake bed in Sweden—5,000 years.

"Recently (1908) Baron de Geer, of Sweden, has reported observations on a post-glacial lake bed in Sweden, from which he reaches the conclusion that the ice did not retire from that region until about 5,000 years ago."

(4). The sub-aerial erosion of glaciated rock surfaces.

"Another striking indication that the retreat of the ice from the main centres of accumulation occurred very recently, is found in the small amount of sub-aerial disintegration of glaciated rock surfaces which has taken place since exposure on the retreat of the ice. Everywhere this has been noticed on glaciated surfaces, upon which boulders are resting. In the places protected by the superincumbent boulders, the original glaciated surface is preserved, but in all the surrounding area the surface has been lowered by sub-aerial disintegration, so that the boulders stand upon slight pedestals. These are everywhere so low, especially in limestone districts that a maximum date of a few thousand years must be assigned to the withdrawal of the ice."

More striking still are the facts reported by Professors G. F. Becker and the late Professor I. C. Russell. Mr. Becker says: "No one who has examined the glaciated regions of the Sierra (in California) can doubt that the great mass of the ice disappeared at a very recent period. The immense areas of polished surfaces fully exposed to the severe climate of say from 7,000 to 12,000 feet altitude, the insensible erosion of streams running over glaciated rocks, and the freshness of erratic boulders, are evidence of this."* Again, Professor Russell, speaking of the region

* Bulletin of the Geological Society of America, Vol. II., p. 195.

further north, in Nevada and Utah, remarks that : " The smooth surfaces are all scored with fine hair-like lines, and the eye fails to detect more than a trace of disintegration that has taken place since the surfaces received their polish and striation. . . . . It seems reasonable to conclude that in an even climate like that of the high Sierra, it (the polish) could not remain unimpaired for more than a few centuries at the most." * The periods in years above given for the close of the Ice Age in North America, are the results of a computation in which various other contingent factors have been considered, and their time-value allowed for. They are not solely the conclusions of Professor Wright, but the results of much collaboration with other geologists, and of investigations extending over many years. If they had been adopted after Drayson's discovery of the second rotation, they would have been sufficiently remarkable; but it can be confidently asserted that Drayson's theory was practically unknown on the other side of the Atlantic to these geologists, until the writer brought the matter to their notice.

If English geologists had been favourable to Drayson, recognition could not have been long delayed ; but, unfortunately for Drayson, not only was he thrust out of the astronomical circle as a disturber of the peace, but his own countrymen failed to take up the cudgels for him, partly because they were influenced by the attitude of astronomers, but more so, perhaps, because they failed to find sufficient indications of a recent glaciation in the British Isles.

The astronomical opinion based on Croll's theory was that the glacial period began with a high eccentricity of the earth's orbit 240,000 years ago, and closed with the beginning of the present period of low eccentricity 80,000 years ago. What, then, is considered to be the *length* of this period, which American and Swedish geologists thus state came to an end at so recent a date ?

After consideration of the rate of movement of glaciers in Greenland and applying it to a process of unimpeded extension over the northern hemisphere, they conclude that the ice-front would extend itself 500 miles in 6,000 years.

This is borne out by the present retreat of the Muir glacier in Alaska, for which there is evidence to show that, while it had retreated fifteen or twenty miles during the last century, it has since 1886 actually retreated on the average at a rate of one mile every three years, a survey having shewn that in 1906 it was seven miles further inland than in 1886.

To quote finally from this same work : " The beginning of the glacial epoch was not so far distant as is popularly supposed. The whole epoch was one in which forces were at work at an abnormal rate, while it is estimated that even now the ice floating away from Greenland as icebergs is sufficient, if accumulated on a land surface, to extend the borders of a Continental glacier about 450 feet a year, or one mile in

* U.S. Geological Survey Monograph XI., *Lake Lehontan*, p. 273.

twelve years, one hundred miles in 1200 years, and seven hundred miles (about the limit of transportation of boulders in America) in less than 10,000 years. It is not surprising, therefore, that so eminent an authority as Sir Joseph Prestwich should conclude that 25,000 years is ample time to allow to the reign of ice of the Glacial Epoch. Certainly there is no need to enlarge this estimate more than two or threefold."

Now Drayson, on astronomical grounds, stated that the Glacial Period was inaugurated 23,000 years ago, and began to pass away 7,000 years ago! The empirical science of geology is thus confirmed by the exact science of geometry with astonishing precision.

CLIMATIC CHANGES.

> "*He (the geologist) rests confident (confident as in the existence of his own being) that the whole history of geological phenomena—the interchanges of sea and land, the recurrence of colder and warmer climates over determinable latitudes, the necessary re-arrangements of life attending these changes, and the like—is but a chronological exposition of the influence of natural law; and, that as law is as obedient to* times *as to* modes, *the periodicity of these occurrences will one day or other be determined. This done, its expression in years and centuries is a simple task; but though accomplished to-morrow and expressed in figures like the distances of the astronomer, the mind would altogether fail to grasp the conception of its immensity.*"
>
> (*From Page's* "Past and Present Life of the Globe.")

The aim of this book is mainly confined to making it clear that a glaciation undoubtedly took place at the date stated by Drayson, and that the conclusions of many geologists receive, on this head, confirmation on astronomical grounds. There are, however, certain aspects of past glaciations, for the right understanding of which the adoption of Drayson's centre of second rotation is also full of promise.

The various bearings of this will be first considered, showing how, apart from Croll's hypothesis of varying eccentricities of the earth's orbit there is sufficient to explain the differences of intensity of glaciation, and even the absence altogether of any glaciation in the polar regions for long periods of time. With the help of Croll the solution of the changes in intensity becomes more easily comprehended as his theory adds

another controlling factor, but since astronomers are not absolutely sure that periods of great eccentricity have occurred, it is as well to treat of the effects of eccentricity separately.*

Some geologists have hesitated to favour the Drayson theory owing to their belief that it implies a recurrence of identical conditions at each glaciation. Drayson, however, enters a *caveat* against this assumption, and it will be seen how the varying intensities are connected with other changes, small in themselves, but cumulative in their effects. It is proposed first to show how various climatic changes would occur resulting from a comparatively slight displacement of the centre of polar motion. This probable slow movement of the centre of second rotation relatively to the pole of the ecliptic has been investigated by Drayson, and the effect of this will be considered. It can be shown, also, that there are changes in the earth's crust, which accumulating from eon to eon, must in the long run affect the position of the centre of gravity of the globe, and hence change the course of the curve traced out by the pole of the heavens.

Movements of the centre of Second Rotation.

Drayson in his book, *On the Motion of the Fixed Stars*, in discussing the assumed motion of the plane of the ecliptic, shows that the observations of 1520 years fail to show any evidence that the pole of the ecliptic has any motion in the direction of the pole of the heavens, but he maintains that there are indications of a movement of the pole of the ecliptic in a certain direction towards that part of the heavens between 120° and 210° of longitude, in which motion the pole of the heavens partakes.

The motion is so extremely slow that the calculations for one cycle of glaciation would not be affected thereby, but it gives a basis for assuming a slow change of longitude for the centre of second rotation, and in a direction opposite to the present movement of the pole of the heavens.

Whilst it is almost impossible to cause the axis of a rapidly rotating body to alter its position in this body, the smallest change in its centre of gravity would cause the axis of rapid rotation to change its direction in various ways.

Therefore, "To conclude," says Drayson, "that because the poles of the second axis of rotation are now 29° 25′ 47″ from the poles of daily rotation, they must always have been so, no matter how much or how little the position of the centre of gravity of the earth varied, is unsound, and is impossible."

"All that can be stated with accuracy is that the present movement of the earth carried back some 15,000 years would cause the Arctic circle to reach below 54° latitude, not in consequence of any change in

* Croll's theory, however, is based on the calculations of Leverrier, who made the discovery of Neptune by a mathematical *tour de force*, which will remain for ever memorable.

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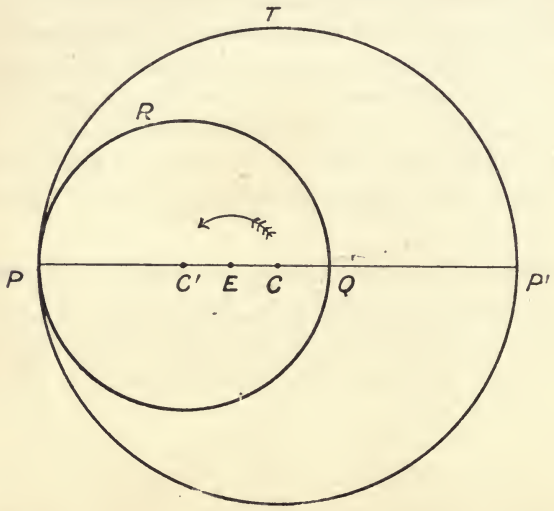
the position of the plane of the ecliptic, but due entirely to the movement now taking place in the earth itself."

How small a movement in the position of the pole of the second axis of rotation would produce a very great change in the climate on earth during this second rotation is shown by the following diagram :—

Figure (1)



N.B.—This figure and the succeeding one supposes the reader to be looking down from the heavens on to the curve traced out by the conical motion of the axis, which is shown in the frontispiece.

The larger circle Fig. (1) represents the course in the heavens, which the earth's axis produced traces at the present time round C, the pole of the second rotation. E marks the position of the pole of the ecliptic.

Drayson, as has been stated, was inclined to believe that there is a relative motion of C round E in a direction opposite to the secondary rotation, which at some time would bring C into the position of C′ (say) 6° on the other side of E. It will be useful to consider what would be the effect of this change of centre of rotation. It is, for our purpose, immaterial, whether it is produced by such a slow circular rotation of this centre, *i.e.*, by change of longitude, as shown by the arrow, or whether it is produced more directly in latitude by a change in the centre of gravity of the earth.

Thus if the pole of the axis of second rotation shifted either slowly or rapidly to C′, *i.e.*, towards the pole of daily rotation when it was near

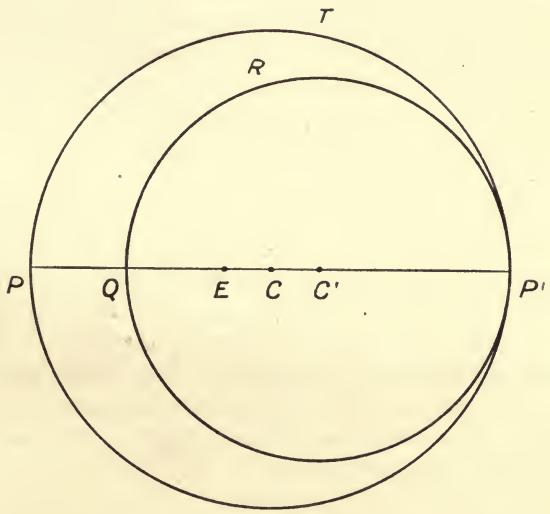
P, then the second rotation would proceed to carry the pole of daily rotation round the circle PRQ. This culmination of a movement of C in whatever way it might be brought about, would initiate a very different state of affairs.

The maximum obliquity will now be PE, 23°, instead of P′E, 35°, of the former curve, and the minimum obliquity will be QE, or 11°.

Since with the present obliquity, the ice-caps are now diminishing, it will be seen that as the pole passes towards R, they might entirely disappear, and a great change of climate be thereby brought about. It would, however, require very many cycles to culminate in such a change of position, and any more rapid change that might have to be accounted for would occur more probably at the other extreme of the cycle, when vast accumulations of ice on the continents are tending to displace the gravity-centre of the earth. Though we cannot be certain of the direction of this shift, we would do well to consider the effect of C moving towards the opposite direction, *i.e.*, towards the pole of daily rotation, when it has reached the point of maximum obliquity, P′.

In the following diagram Fig. (2), we will now suppose that the point C , originally 6° from E, is moved to C′, 12° from E.

Figure (2)



If this occurred when the pole was at P′, the maximum obliquity point of the original curve PTP′, then the second rotation would proceed to carry the pole of daily rotation round P′QR, so that the minimum obliquity would become QE, about thirteen degrees, while the maximum obliquity P′E remained unchanged.

From the foregoing diagrams it will be seen how all the various climates to which geology testifies, can occur, without postulating any extravagant theories to account for them. The duration of much more genial conditions than now exist for very long periods of time, with ice-free and warmer seas at the poles are natural phases, incidental to the movements of the pole of second rotation.

Again, our latitudes in their turn might form a rainless zone, so that areas now remote from desert conditions would become arid and lifeless ; thus explaining the sterile layers of the cave deposits, which have given rise to some speculation. Finally, under the conditions of Fig. 2, the glaciation would remain intense for a much shorter period, while half the cycle would be spent under conditions of comparatively slight obliquity, remaining for some 10,000 years much less than it is at present. Such alternations might account for the method of occurrence of the several coal seams, which succeed each other at regular recurring intervals. Moreover, on the passing of the glacial climate, the "sporogenous" character of this vegetation would enable it to quickly resume its former domain.

That these alternating phases of climate have occurred there is, in geological history, abundant evidence ; and, notably, of such as permitted sub-tropical growth in the higher northern latitudes, and of the coal-seams being laid down in the Antarctic continent, which have recently been discovered. Until now it has been impossible satisfactorily to account for all this. Attempts have been made to attribute such phenomena to a change in the position of the axis of daily rotation, but this has been well considered by various mathematicians, who have definitely pronounced such a change to be impossible. Viewed in this new light the extraordinary polar climates of times gone-by are given a rational and probable explanation.

The glaciations that have evidently taken place in the early geological history of the earth, extending on more than one occasion to the borders of the Tropics, have hitherto seemed inexplicable. Judging from the analogy of what has been advanced, it would be irrational at present to seek any other cause for this. When we know more fully the possibilities of gyroscopic movement possessed by our globe, the extremes of obliquity required to correspond with these phenomena may be found to be a direct result of certain forces, whose action, in our present state of ignorance, is quite obscure.

Past Climates.

The complicated machinery, which produces climates, makes it impossible to assert what the climate of a particular area would be under different obliquities. Geological reconstructions are generally unsatisfactory, but the above diagrams suffice to show that one cycle of glaciation, by inducing a small change, might, when favoured by secondary

conditions, develop a very different state of affairs. Thus, if geological evidences of deposits, or of flint and bone relics, exhibit a succession of cold and warm climates, or even desert conditions intervening, these alternations instead of being perplexing, may serve in their turn as direct evidence of the prevailing astronomical condition of the period under consideration.

The conditions of aphelion and perihelion as the secondary causes of a change in the centre of second rotation must be now briefly reviewed. At the present period there are no conditions accompanying the phases of obliquity, which are likely to make for a change in the intensity of the next glaciation to come. The degree of ellipticity of the earth's orbit now is low, that is, there is no marked difference in the aphelion and perihelion distances of the earth from the sun, only about a million miles. Under these conditions the glaciations of the Arctic and Antarctic would proceed equally, except in so far as there is, in general, a greater continental mass in the northern hemisphere ; but supposing, on Croll's theory, the conditions of ellipticity to become high, we should have to consider the effect of a difference of distance of the sun between aphelion and perihelion as great as 14,000,000, or even 17,000,000 miles. Then if the northern hemisphere had its winter in aphelion at a time of maximum obliquity, it would be much more under glaciating conditions than the southern hemisphere. The difference also in the amount of preponderance of land in the northern hemisphere would be greatly accentuated by the vast accumulations of ice on its more extensive continental area, and it can be imagined that the centre of second rotation might thus be, comparatively rapidly, compelled to change its position to a very marked degree.

It must be borne in mind that the changes from low ellipticity to high ellipticity require enormous periods and are not regular. The two last periods of high ellipticity are said to be a million years ago lasting for about 300,000 years, and again about 300,000 years ago, but this was only of 200,000 years' duration.

Now geologists concur in the opinion that among the ice-periods there was one dominating and stupendous glaciation, compared with which subsequent glaciations only appear as ice-sheet advances of small magnitude. During both these occasions of high ellipticity there was a recurrence of the proper conditions for promoting excessive production of ice in the northern hemisphere with proportional diminution of the glaciating conditions in the southern so that we can thus establish definite stages for the march of events. Conversely we may look to periods of low ellipticity to account for the weakening of the rigour of glacial action, which, combined with diminished obliquity of the earth's axis, would produce the conditions in the polar regions to which geology bears witness, but has hitherto been unable to explain.

Thus the mystery surrounding past conditions of climate exists no longer to the same degree as before, since definite causes can be recognised to be in operation to produce these effects. In the inchoate state of the comparatively new science of geology, it must yet be long before we can gauge the effect of the changes going on at the present time; what sea bottoms are rising; what land is sinking; and what internal stresses are at work on the crust; but there are certain notable facts which enable us to form some idea of the forces in operation tending to produce a change in the disposition of land and sea, and a consequent slow displacement of the gravity centre.

If one looks at the map of the world, there is open to view the fact, to which no attention has hitherto been called, namely, that the trend of the ice-sheets and glaciers has always been to the westward on the coasts that come into the zone of ice action, forming bays, lochs, and fiords, while the east coast is not affected. The difference is not so marked in Greenland, but it is certainly in favour of the west coast, while in Scotland, Norway, Finland, Iceland, Patagonia and New Zealand, all countries subject to glaciation, it is the rule without exception. The fact that most lochs and fiords have been carved out by ice is no longer a subject of controversy,* so that one is free to conjecture that the cause of these being found on the western coasts must be the inertia of the ice masses, combined with the ice property of facile movement; this being brought under the operation of the tidal effect of the moon, is sufficient to assist the lag in the direction opposed to the daily rotation, but not to overcome it in the other direction.

Experiments of late years have shown that the same is true in a minor degree of continental masses under tidal stress. Herr Wegener, of the Marburg University, has lately announced as a result of scientific observation and calculation, that all continents are capable of both vertical and horizontal motions. Horizontal displacements are said to be continually occurring, as is shown by variations of distance between the continents. Thus, lunar observations have proved that Greenland during 84 years has receded from Europe 3,083 feet. Also determinations made at different times by means of the transatlantic cable of the distance separating Greenwich from Cambridge, Massachusetts, has shown that North America has receded from Europe about 295 feet. In view of the constant slipping of the ice sheets westwards it is only a short step to assume that similar forces are at work on the mobile earth-crust, and that *ceteris paribus*, the tendency to displacement of continents in general is also in the same direction.

When this fact is taken in conjunction with the known effects of a slight shift in the pole of second rotation, the significance of this movement

* This question, however, has just been re-opened by J. W. Gregory in the *Nature and Origin of Fiords*, but the above fact, and the soundings of the lochs in Scotland, go far to establish the writer's contention.

is obvious as one of the factors that tend to produce a sustained and continuous change; so that there is no haphazard movement, but in all probability a steady and definitely directed force always in operation.

Our Present Climate.

Again, in dealing with such incomprehensibly long periods of time, there is a change, which we know is everywhere taking place, namely, the wearing down of high mountains and table lands. Much as our climate depends on the limits of the Arctic circle, still more depends upon the character of the earth's surface within that circle. If erosion and subsidence were to some day transform Greenland into a cluster of low-lying islands,* other things being equal, we should have a very different climate to the present one in these latitudes, because from the elevation of Greenland from 6,000 to some 10,000 feet, it acts as a vast refrigerator and factory, with an enormous output of icebergs, which is only rendered possible by its elevation. In a map of the world, showing in graded shading the general elevations of the land, the loftiness, extent, and singularity of this great continent, stand out as the dominating factor in the control of our climate.†

Of all the theories advanced to account for the vagaries of our weather none seem to have really defined any operating cause. One source alone of prophetic utterances seems to be able to claim a fair proportion of correct forecasts ; namely, those of Dr. Bassett, based on the surface salinities and temperatures of the seas round our coasts.

These prophecies are mentioned because they appear to be only the secondary effect of the process of the breaking-up and retreat of the Arctic ice-fringe. The greater the amount of ice released and discharged southward into the Atlantic, the greater the effect on the surface salinity and temperatures of the Gulf stream.

A scheme has been outlined in America for neutralising the effect of the Labrador current by the building of a rip-rap jetty about 200 miles long, extending eastward from Newfoundland to near Cape Race.

This project is not so fantastical as it may seem, in that if the cold Labrador current could be turned eastward it would be sunk so far when the Gulf stream met it, that the latter warm ocean river would pass over the great cold river from the North Pole. The warm flood of the Gulf stream 40 miles wide and 200 feet deep, with a temperature of about 70° Fahrenheit, would flow eastward and northward with undiminished strength, instead of as now being neutralised by the mingling of its waters with the cold Labrador current.

The mixing of the waters of the two streams, which now takes place, is, according to Dr. Bassett, one of the main causes of the un-

* In 1892, Capt. Peary when in latitude 82° N writes that "on looking northwards at a distance "of some 60 miles he saw what seemed to be a group of islands having no ice caps. Between the "foot of the great ice slope and Independence Bay there were hills and valleys where grass grew "abundantly, and on this herds of musk oxen were feeding."

† See *Atlas of the World's Commerce* (Bartholomew).

certainty of our weather:—"The variations of the Gulf stream drift are annual changes of an irregular nature. Increased salinity and temperature is due to a larger proportion of water from the Equatorial regions, while diminished salinity is caused by an increase in the amount of Arctic water."*

With a view to ascertaining the movements of the break-up of the ice, a vessel has been fitted out by the Board of Trade to carry out this work, fitted with wireless apparatus, and can thus give valuable information to shipping in the Atlantic. This scheme should, however, be extended to the stationing of vessels much further north.

We know really little about the conditions to the northward of Labrador, and even that is from surveys of long ago, before the accelerated change began, and nothing of the process of berg and floe accumulation in the neighbourhood of Davis' Straits, where the sea is less deep. We know that bergs coming down the east coast of Greenland are drifted round Cape Farewell, and up the west coast as far as these Straits, and at the same time bergs are being detached and launched from the Baffin Bay coast southward with the prevailing current, on the other side of the Straits. A change in the strength and direction of certain winds, combined with an extra amount of ice to go southward, might delay the usual course of the drift until all the bergs were frozen into the packs again,† and for that year the Atlantic might be free of ice, and our summer as in 1911, very fine and warm. For this boon it seems that in the next year, 1912, we had to pay a heavy price, as it is probable that the combined amount of two years came down at one time, and we thus had to deplore the loss of the "Titanic," and to record an atrocious summer.

Temperature Changes.

It has been urged as an argument against postulating any real change of climate, that statistics do not show any increase of mean annual temperature. On a yearly average that is quite probable, even with great extremes of heat and cold ; but records have been kept lately in the south of England, which show that the temperature of December, January, February and March of last winter was 2° F. higher. What is remarkable is that throughout the whole of the winter season the temperature has been continuously above the average.

We can better appreciate what this implies, when the effect of the converse condition is considered. We have on the authority of Professor Hobbs, a statement in *Characteristics of Existing Glaciers*‡ that "a fall of

* See *The Hydrographic Work in the Irish Sea during 1909*, by Henry Bassett, extracted from Prof. Herdman's "Report on the Lancashire Sea Fisheries Scientific Investigations for 1909," Trans-Biological Society of Liverpool, Vol. XXIV., 1910.

† On going to press, the writer has come across the following from the *P.M. Gazette* of April 15th, 1912: "Last Tuesday, when three days out from Halifax, the Cunarder 'Empress of "Britain' encountered an ice field 100 miles in extent with enormous bergs . . . the bergs appeared "to be joined to the ice field."

‡ Macmillan.

about 3° F. in the average temperature of Scotland would result in the formation of small glaciers within the area of the Western Highlands." Thus we can infer that a change of 2° even, in the ascending direction, would produce very marked results; and, indeed, there seem to be indications that Nature is responding to this change in many unexpected ways. The time for blooming does not follow the months with the same regularity as heretofore; some plants have asserted themselves with greater vigour; others have shot up to an unusual height; and naturalised shrubs like the *Laurestinus* and *Veronica* have blossomed in entire disregard of the calendar.

With regard to the possibility of a much more temperate climate supervening, as sketched on page 56, and forming an inter-glacial "episode" similar to those of the past which have left their traces interspersed between deposits of glacial débris, there is much to be learnt from a study of a very instructive area in the valley of the Inn.

This valley has supplied Professor Penck with one of his most important evidences of the four glaciations alluded to on pages 53 and 54 preceding the above. Here interstratified between the boulder clay of the last glacial "episode" and that of the penultimate glacial "episode" is a deposit known as the "Hötting breccia" (so-called from a neighbouring village). This breccia represents from its fossil contents, an inter-glacial or genial epoch. The species are mainly those now found in these latitudes, but the present invaders from the more northern regions are apparently excluded, while on the other hand several southern species are admitted. Professor Penck therefrom concludes that the climate of Innsbruck in the days of this breccia was 2° C. (3.6° F.) higher than it is now. In correspondence with this the snow line stood 1,000 feet above its present level.

Respecting this, Professor Sollas in *Ancient Hunters* further writes: "The region round Hötting furnishes us with evidence of revolutions of climate on the grandest scale; the lower boulder clay representing the third glacial age, witnesses to a time when the snow-line of the Alps had descended 4,000 feet below its existing level, and the valley of the Inn was filled with ice; the Hötting breccia, representing the third genial age, equally testifies to a time when the ice had disappeared and the mountains had been relieved of their mantle of snow."

That such great changes can be brought about by such a small rise of average temperature as 2° C., is somewhat surprising, but appears to agree with the conclusions of Professor Hobbs already alluded to, and to emphasise the importance to us of any small quotum of increase in the direction of a milder climate in the British Isles.

These glacial and genial episodes of Penck are regarded by him as eight periods in all, and are erroneously supposed by some to include the last glaciation, but from researches elsewhere we know that there has been more than one subsequent to these. This geologist has made

great strides in our knowledge by his investigations, but has worked mainly on the diagnosis of the different periods with little regard to the time involved. When the eight episodes are once recognised as four cycles of some 30,000 years' duration, we shall probably obtain a much more definite history regarding all the points which come under geological review.

It is not only our climate for which we must make the glacial cycles responsible. If environment has played the part assigned to it, it will be seen how ceaselessly the forces of Nature and natural selection were in operation. Without the auxiliaries of changes of climate the world would have stagnated, and been less varied in every way than it is at present. The diversity of animal life, of vegetable growth, and of scenery is largely due to glacial epochs. Thus it is found that all the most picturesque scenery is just where the operations of ice have been conducted on the grandest scale.

It is difficult perhaps at first to conceive how in the struggle for existence minute specific differences promote the extinction of one species, and the predominance of another, but it is easily understood in the vegetable world when regarded as under the influences of changing temperature. Every seed has its fixed temperature for germination, and is so predestined by the specific constitution of its protoplasm to be sensitive to the minutest changes. Hence a small rise of temperature will admit of an alien invasion, or give one plant a start early in the season, of which it will take selfish advantage, and thus upset the balance of power in the vegetable world ; and—partly owing to such changes—analogous forces are at work, but in a more subtle and limited degree, in the animal kingdom.

In reviewing the history of mankind one sees in the evidence of caves and " drift " of the temperate zone an alternating pageant in the same area, of sub-tropical and cold conditions ; of man and the mammoth and woolly rhinoceros in close relationship, followed by the horse and early type of ox ; then again a period of reindeer and Arctic animals, succeeded by a more temperate fauna ; with indications of an intervening condition in which the same area was desolate and untrodden by man or beast of any kind. What does this denote, but that the alterations of obliquity are entirely responsible for the dissolving views thus represented ? And, how are we to arrive at an estimate of the length and duration of such periods except by a fuller knowledge of the polar movement of the earth's axis for which Drayson supplies the initial data ?

The considerations which have influenced Dr. Allen Sturge in his investigation of Neolithic glaciations* must in the main form the basis of all future estimations of this nature. Whether he is right or only partially so, he has certainly indicated the outlines of future research under the guidance of Drayson's astronomical clue. Only those who are

* Proceedings of Pre-historic Society of East Anglia (1913).

familiar with the specific individuality of flints, both in molecular structure and patination, and unprejudiced as to the enormous extent assigned to the age of man, can rightly appreciate the extraordinary history he has lately outlined.

The writer is tempted to give an epitome of the nature and extent of these researches, but except in so far as they conclusively prove that a glaciation took place in England during Neolithic times, they are beyond the scope of this work.

The great antiquity of man is the feature that creates perhaps the most prejudice. This, however, is mainly due to hereditary and traditional ideas, and could be overcome by many proofs, which exist, but which have not been brought forward, either because of this prejudice, or for want of a time-unit such as Drayson supplies.

Apart from the evidence of cave deposits which have not been fully studied in this particular, nor dealt with in any comprehensive fashion for obtaining a time factor, there is evidence accumulating to show that man, supposed hitherto to be confined to the Pleistocene period, may be traced far back into the Pliocene, and from the diverse nature and intelligent manufacture of his flint implements must have been even then possessed of the characteristics which differentiate him from the anthropoids, both in type and mental capacity.

It is fashionable for the moment to deride these evidences and to regard them, as formerly in the case of the now "accepted" paleolithic implements, as *lusus naturæ*, or chance products of trituration and percussion ; but there are surprises in store for this school of antiquarians, who in their turn will have to admit a much wider extension of the term "paleolithic," both in time and geological horizon.

Day by day it is becoming more evident that we must enlarge our ideas regarding man's sojourn on this earth. What is contained within the four corners of history is but a small portion of one glaciation cycle, and is but as the last ring of growth to the whole lifetime of an old oak tree.

A CRITICAL SUMMARY.

The objections to any new discovery are generally entertaining reading, and those advanced against Drayson's theory form no exception, reminding one of the learned Sizzi and the philosophers of his time, who, when Galileo, by the aid of a telescope had discovered the satellites of Jupiter, harangued against him in this wise :—

> "There are seven windows given to animals in the domicile of the head, through which the air is admitted to the tabernacle of the body—viz., two nostrils, two eyes, two ears, and one mouth.

> So in the heavens, as in a microcosm, there are two favourable stars, Jupiter and Venus ; two unpropitious, Mars and Saturn ; two luminaries, the Sun and Moon ; and Mercury alone undecided and indifferent. From these, and from many other phenomena of a like nature, which it were tedious to enumerate, we gather that the number of planets is necessarily seven. Moreover, the satellites are invisible to the naked eye and therefore can exercise no influence over the earth, and would, of course, be useless ; and therefore do not exist."

Apart, however, from such puerile criticisms, which it would be merely tedious to mention, there were some certainly which were sound and well directed, but Drayson, in every case, was well able to hold his own. Many critics on the announcement of Drayson's discovery, then, as now, appeared to have misunderstood the position, pointing out that it was not in conformity with the text books. One critic naively urged that as the present system worked very well there was no need to introduce a new theory ; while another, who was an authority of that time, explained the movement of the pole as " for small angles a circle, but for large angles not a circle,"* which he apparently considered a satisfactory condition in which to leave the question. It was also continually stated to be absurd or impossible that the earth's axis should do this or that, without any attempt being made to prove what the path of the pole really was, or to defend the orthodox position of a moving centre for the circle of the pole of the heavens, by any sort of argument.

The most serious of the criticisms, now presented, suggest that the small arc of the curve that forms the basis of consideration, might give approximate results in calculations with other centres ; as in the following :

> " Drayson is really assuming that a curve is a circle because a portion of its circumference 2° long is not distinguishable from a circle. His point C is nothing but the centre of curvature of the pole's path for the ' moment of time ' which is represented by the period 1500 to 1900 A.D."

The only remark to be made on this criticism is that Drayson can go beyond the limits of time above stated, and can prove that he has found the real centre by numerous intricate calculations regarding star positions, impossible at present to astronomers. Drayson's centre, moreover, does not labour under the disability of the orthodox centre of decreasing its distance from the circumference.

One of Drayson's most influential and determined opponents wrote in 1906 : " If you take a fixed point, say 24° from the pole of the heavens, and a corresponding angle you will for short periods obtain almost exactly similar results, hence you have not proved our theories wrong."

* The same argument has been repeated quite recently.

In putting forward this objection the critic forgets that he is giving up the orthodox theory of a moveable point as the centre of a circle. He cannot with 24° radius and a fixed centre explain the recorded decrease in obliquity given from 1590 A.D. until now. It may be added that he cannot explain the cause of the climate of the Ice Age, nor give its date and duration, nor say why it was contemporaneous in both hemispheres.

On a recent occasion the same professor wrote : " There is no chance of Drayson being right in his reasoning. Unknown causes (the discovery of another sensation like radium) might bring his result about (or any other unlikely result), but they would never make his *reasons* right." It is evident that even if the results of Drayson's theory *are* brought about, the miracle will consist in getting this astronomer to admit them !

Perhaps the most extraordinary feature of the question is that writer after writer, after dilating on all possible and impossible theories to account for the glacial epoch, seems invariably to dismiss Drayson in a few words. Dr. Croll says : " The theory of a change in the obliquity of the ecliptic has been appealed to. This theory for a time met with a favourable reception, but, *as might have been expected*,* it was soon abandoned." (Discussions on " Climate and Cosmology "). Drayson's remarks on this and on some of Croll's statements in general, are amusing reading. In a lengthy series of very able and exhaustive articles contributed to *Countryside* on *Theories of an Ice Age*, by the Rev. M. Davidson, F.R.A.S, there are only two short paragraphs devoted to the Drayson idea, concluding with these words :—" As, however, such an obliquity never existed, it is almost unnecessary to discuss the question further."

There seems to be a general agreement that this question must be " taboo," which apparently has exercised a paralysing influence on the only geologist who had frankly accepted Drayson. It is somewhat remarkable that an authority on the Ice Age, who two years ago wrote: " Your theory (*Why we may expect warmer winters*) is correct and most welcome," should have recently published a book assigning dates wholly in accord with Drayson, without deeming it necessary to mention his theory ; and, indeed, is at pains to say that astronomy can give no aid to geology. The present writer is indebted to this geologist for providing such an object lesson of the difficulty of obtaining recognition of a new idea.

The attitude of mind in general regarding the supposed heresy of not blindly accepting the authorities is well illustrated in the following story told by Drayson of the reception that he met with, when, as a young man, he put forward a simple solution of the motion of the satellites of Uranus.

Uranus was discovered on the 13th March, 1781, by Sir William Herschel, by aid of a large telescope. He announced also that this

*No italics in the original.

planet possessed satellites, which presented a remarkable contradiction to everything else in the solar system.

In Sir John Herschell's " Outlines of Astronomy," Art. 552, this wonderful contradiction is stated as follows :—

" The orbits of these satellites offer remarkable and indeed quite unexpected and unexampled peculiarities. Contrary to the unbroken analogy of the whole planetary system, the planes of their orbits are nearly perpendicular to the ecliptic, being inclined no less than 78° 58′ to that plane, and in these orbits their motions *are retrograde* ; that is to say, their positions, when projected on the plane of the ecliptic, instead of advancing from *west* to *east*, round the centre of their primary, as is the case with every other planet and satellite, move in the opposite direction.

" A trifling oversight," says Drayson, " was committed, viz., that of not noticing that the south pole of Uranus was turned towards the earth in 1781, when it was discovered.

" The above erroneous statement was copied and re-copied in every book on astronomy, and came to be accepted as an absolute fact, upon which theories could be firmly built.

" The pope of theorists examined the supposed fact, and after due deliberation, announced that before the whole solar system was gradually shrivelling up from the nebulous condition in which it had first existed, an interloper from some other nebulous system, which was twisting round in the opposite direction must have forced itself among the orderly planets belonging to the sun.

" That a planet, whose axis was situated very nearly in the plane of its orbit should present its south pole to the earth, when in one part of its orbit, and its north pole when 180° from the first-named position, was too simple a fact to be comprehended.

" It was about thirty years ago (1860) that having occasion to examine this problem I at once perceived that Uranus at one point of its orbit would present its south pole to the earth, and about forty-two years afterwards would present its north pole to the earth. When the south pole was presented to the earth the satellites would move round Uranus in the same manner as one deals at whist. When the north pole is seen from the earth, then the satellites move round in the opposite direction to that in which one deals at whist.

" Surprised that so very simple a geometrical law should have puzzled the learned gentlemen who had written on this subject, I prepared a paper with diagrams, in order to explain the laws which produced the effects.

" Being young and inexperienced at that time, I believed that the solution of the supposed mystery would very likely be well

received by a society formed for the ostensible purpose of eliciting truth and advancing real science.

" I was not prepared for the results which followed the reading of my paper, and the proofs I gave of the true cause of the apparent movements of the satellites.

" Instead of the diagrams proving the truth of my conclusions being discussed, or even examined, it was stated that it was a piece of unwarrantable impertinence for a mere artillery officer to question the infallibility of those authorities, who had stated what they had about these satellites. If the explanation which I had given were correct, of course the great authorities would themselves have found this out.

" A senior officer, who was more successful in holding on to the skirts of those who possessed patronage than he had been for any exhibition of a knowledge of science, considered it his duty to write me an official letter, in which he stated that he should report me to superior authority for having so far forgotten myself as to question the accuracy of the admitted authorities of the time in matters of astronomy, and that he should recommend that I be removed from my appointment.

" In one or two of the modern works of astronomy it is now stated that the peculiar movements once supposed to occur in connection with the satellites of Uranus, *may* be due to the position which the axis of Uranus occupies with respect to its orbit."

The above was written in 1890.

So far ample circumstantial proofs of the real polar movement have been given. To cite the various calculations as culled from Drayson's writings, is out of place in this work, and in view of the complete investigation made by Admiral Sir A. de Horsey, in *Draysonia*, quite unnecessary. It is proposed, however, to give some tables of comparison between Drayson's calculations and recorded observation, which are a striking testimony to the accuracy of his data.

Discrepancies appear from time to time in the fixing of star positions, which have given Drayson an opportunity of applying his superior knowledge, and this he has demonstrated by more than one example. Again, in olden times, calculations of obliquities differ with various authorities, owing to refraction or inferior instruments, and Drayson is able to discriminate the probable sources of error and to establish which is the most correct. His knowledge further accords to him the power of posing as arbiter in a dispute which took place in 1775 between English and French astronomers regarding the mean obliquity for that year, and shows that the palm must be given to the English observers for accuracy, for had they used a modern table of refractions, they would have come within 1″ of the obliquity of that date.

Below are given some results arrived at by calculation and compared with recorded observations :—

MEAN NORTH POLAR DISTANCE OF THE POLE STAR.

Date.	*Recorded observation.*	*Calculated by Drayson.*
1887 ..	1° 17′ 38″ ..	1° 17′ 38″
1873 ..	1° 22′ 4.3″	1° 22′ 4.5″
1850 ..	1° 29′ 24.7″	1° 29′ 24″
1819 ..	1° 39′ 25″ ..	1° 39′ 25″
1755 ..	2° 0′ 18.9″	2° 0′ 20″

There is no star in the heavens which gives such a severe test of the true course of the pole of daily rotation as does the pole star. The annual rate at which the pole decreases its distance from the pole star is very variable, and it would be impossible for a faulty method of calculation to be accurate under all conditions. Consequently, when it is shown that the polar distance of this star can be calculated for a hundred and thirty-two years to within 1″, the correctness of the formula applied is established beyond doubt.

The following are some calculations of obliquity compared with observation records. After showing that for the past 76 years they never differ even by one second, he goes further back still, with the following :—

Date.	*Obliquity by observation.*	*By calculation.*
1795 ..	23° 27′ 58.3″	23° 27′ 57.6″
1690 ..	23° 28′ 48″	23° 28′ 47″
1590 ..	23° 29′ 52″	23° 29′ 53″
1437 ..	23° 31′ 58″	23° 32′ 12″

The above calculations speak for themselves.

When discussing the changes of zenith and meridian that take place all over the earth to a varying degree, due entirely to this second rotation, which is not even suspected by astronomers, Drayson points out how all the errors arise which induce them to ascribe " proper motions " to various stars, and to consider that the perpetual observation of them is rendered necessary thereby.

It is the general impression that astronomy has attained the acme of correct observation and precision, but one may ask why then this close and continuous observation ? To claim that it is necessary to make annually some hundred observations of a star is virtually an admission that we are far from perfection. The earth itself is the most complete astronomical instrument that can be imagined. May not these uncertainties be due to a wrong interpretation of its movement, producing the same kind of error as would a faulty construction of the transit instrument ?

That observations can now be made with great accuracy is no more a proof of perfection than it was in the days of Ptolemy. Ancient observers could foretell with very fair accuracy when an eclipse would occur, when a star would be occulted, etc., etc.; and yet it was believed

that the earth was stationary, and neither rotated every twenty-four hours on its axis, nor revolved annually round the sun.

Perfection recorded to thousandths of a second is really only an advertisement of the *Vernier* and other devices for insuring accuracy of reading. It does not follow that the fundamental beliefs regarding the movement of the earth-instrument are incontestably established.

The superiority of calculation is not merely economy of time, but it produces more accurate results. Observation of the stars, when the true movement of the earth could be employed for calculation would be as unnecessary as observation of sunrise and sunset to find the length of day. All the varying and uncertain conditions of the atmosphere, which would tend to make the above an intricate operation have their analogy in questions of refraction, personal equation, &c., which have now to be considered, and which as sources of error could be eliminated.

Accurate details as regards the pole star have here been shown possible of attainment by Drayson's calculation ; it is evident, therefore, that as the polar distance of this star can be calculated to within one second for a hundred and thirty-two years, repeated observations of this star, in order to predict its distance from the pole at future dates, is quite unnecessary. So also is it with a multitude of other stars, and as the effect of refraction is always an item of some uncertainty, calculations must give more accurate results.

The saving also in actual money would be considerable. The effect of adopting Drayson's second rotation as the movement of the pole would be to economise the labour of a large staff—the appropriation for which runs annually into a figure represented by many thousands of pounds—and set them free for more important work in other branches of the science ; and this, not only in our own observatories, but all over the world.

In a letter written by Admiral Sir A. de Horsey to General Drayson in 1894, the former gives succinctly a statement of what Drayson's discovery enables an ordinary mathematician to achieve. After describing various tests of the theory to calculate the right ascension and declination of several stars he goes on to say :—

> " Determined to apply a crucial test I selected the stars *lambda* Ursæ Minoris, close to the North Pole, and *sigma* Octantis, close to the South Pole, stars having an annual variation in right ascension respectively twenty-fold and thirty-six-fold as great as the average. Calculating *lambda* Ursæ Minoris from 1850, I found its right ascension and declension in 1895 to be within 0″.249 and 0″.065 respectively of the results by observation (and by rule of thumb for four years in advance) recorded in the *Nautical Almanac*. Then calculating *sigma* Octantis from 1875 I found its right ascension and declension for 1895 to be within 4″.251 and 0″.28 respectively of the *Nautical Almanac* record. Astronomers will think little of a

difference of right ascension 4½ seconds in the case of a star which, in the twenty years changed 2,141 seconds, and which being within 44′ of the pole, must hang on the transit wires of the transit instrument for a considerable time.

" I am fully aware that the above calculations are unknown to all astronomers to whom you have not explained your system. They are problems, which any one with ordinary mathematical ability can work, if he knows your system. Without this knowledge, and without accepting your discovery to be true, I believe no man living can work them. To the Astronomer Royal to the Royal Astronomical Society, and to all the learned professors in the four quarters of the globe, who adhere to their text book knowledge, I believe these problems to be as insoluble as they would have been to Lobengula's medicine man. I am of a rather sceptical turn of mind, deeming that when in search of scientific truth, one should take nothing on trust. As you know, there are two or three minor points in one of your published works, in which I differ in opinion—perhaps owing to my incompetence, possibly owing to your having been mistaken—but these are trifles. With regard to your system of the second rotation of the earth, if one or two calculations only had agreed with observation, I should have said it was very extraordinary, but might possibly be a coincidence. But when I find that in no single instance has calculation failed to obtain results, which are true, and which are unobtainable by calculation from any theory differing from your system ; when I find that by your great discovery I am enabled to calculate with precision the obliquity of the ecliptic, the precession of the equinoxes and the polar distances, and right ascensions of stars for 5, 50, 500 or more years past or future ; when I find that a precise and unchangeable standard of time is obtainable from your systems for all time to come instead of the present erroneous measure . . . . . ; when again I consider that your system establishes the period of successive glacial epochs, and the date of the last one ; . . . . when all the above results are considered, I can come but to one conclusion, viz., that the truth of your system is established beyond all doubt, and that this truth must shortly force itself on the scientific world.

" It is inconceivable to me that the Royal Astronomical Society has not enthusiastically taken up a subject which gives such strong evidence of its truth. To sift such a matter—a matter affecting the basis of all astronomical calculations—to the bottom, is surely the first duty of a learned Society which has the privilege of the prefix " Royal." I should have imagined—as I believe you did—that you had only to whisper 29° 25′ 47″ in order to put astronomers on the *qui vive* to elucidate a discovery of enthralling interest, which for a chaos of supposed proper motions of millions of stars

substitutes a simple movement of the instrument (the earth) by which and from which all astronomical observations are made. . . ” This letter is given in full in *Draysonia*. The paragraph attached to it contains a further important statement :—

“ Since writing the above I have tested Drayson's system conversely, *i.e.*, totally ignoring his data, and working only from observed positions of stars as recorded in the *Nautical Almanac*—data which no one can dispute—I calculated by my own independent method the radius of the circle as described by the pole of the earth, the annual motion of the pole, the angular distance between the poles of second rotation and ecliptic, and other fundamental items, bringing my results out to agree with Drayson's data with sufficient accuracy to confirm their truth. This I did by six different calculations, viz., with Polaris, *beta* Orionis, two of *alpha* Draconis, and two of *alpha* Virginis. These tests are to my mind conclusive, because their results could not all coincide with Drayson's data, if the latter were not correct.

“ Not only has no proof ever been given against General Drayson's system, which was worth even half-an-hour's examination, but proof after proof has been given of its accuracy. . . .”

When many years ago Drayson submitted a paper to the Geological Society, in which he gave those very dates for the glacial period, which are now found to be accurate, the Society pronounced that they were wrong. When he submitted the astronomical portion of his discovery to the Royal Astronomical Society and invited a discussion, his paper was suppressed.

There is nothing unusual or extraordinary in the refusal of authorities to accept this new idea. It has been the invariable fate of exponents of new ideas to be pilloried or neglected. That is why advance hitherto has been so slow. Witchcraft, heresy, mania, are the accusations thrown at the heads of men who have the audacity to interfere with established beliefs. Drayson, if he had lived earlier, might have been haled before the Inquisitors, and perhaps burnt at the stake. In our times he incurs contemptuous neglect as if he suffered from some mental aberration. The far-reaching scientific importance of his discovery, strange to say, made his task more difficult. It is pathetic to think that beyond a small circle of friends he never obtained even the slightest recognition.

Together with official prejudice Drayson had to deal with an inert public opinion, which in his time was much less competent to grasp scientific ideas than now. He had, moreover, to overcome a traditional reverence for astronomy, which goes far back in the history of mankind. Something of the awe in which the savage holds the witch-doctor still survives in modern civilised man, dating from the times when he began to till the ground, and astronomy first took shape as a science.

The heavenly bodies were for signs and for seasons, when to sow and when to reap, so that for long ages this was the only science worthy of the name. Hence the Megalithic Age, with its high mounds and monoliths, obelisks and pyramids, whose shadows pointed the dial of the seasons, serving often the double purpose of observatory and mausoleum. These old-time observatories, which enshrined the cult and myths of the people, were jealously guarded by the priesthood, who were thus forced to be extremely conservative. No other science, consequently, has undergone at times such demolition as astronomy. The edifice built with such a promise of permanence has had more than once to be reconstructed on the advent of some new discovery.

Something more is now required from astronomers than the invocation of the great name of Newton in support of a circle with a phantom centre. This philosopher, when he made his great discovery of the mechanism of the universe in the laws of motion, naturally applied them to the finding of a cause for Precession, but Newton was not confronted with geological research, and knew nothing of the decrease in the obliquity, nor the true conformation of the earth. Are his conclusions, then, never to be questioned ?

We are not more capable, certainly, than the great minds of the past, only better equipped. Not to use these advantages will be to incur the reproach of the age of Galileo. Let the facts here outlined be faced, and admission made that much yet remains to be investigated, and Drayson, ere long, will be assigned his place among the Immortals.

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APPENDIX TO PART III.

The Acceleration of the Moon's Mean Motion.

Simple as are the Laws of Motion in themselves presenting no difficulty of application to the action of one body on another, they have, however, when a third body is introduced, and with all of them in motion, a very different aspect.

The complications introduced and the difficulty of determining their relative positions, is said to transcend the power of mathematical methods. This "problem of three bodies," as it is called, can in consequence only be solved by taking special cases. A scientific contributor to the *Pall Mall Gazette*, over the initials "E.S.G.," writes as follows :

> "The most interesting special case is that of the movement of the moon, which for the purpose of this problem is one of the 'three bodies,' sun, earth, and moon.
>
> "This problem was attacked during the nineteenth century by three mathematicians. Two of them, Hansen and Delawnay, failed. The third, G. W. Hill, of America, devised a new method, and now, after fifteen years of unremitting labour, E. W. Brown, of Christ's College, Cambridge, and now a Yale professor, has reduced Hill's mathematical formulæ to arithmetical form, and so far as the moon is concerned, we are at last in a practical possession of complete solution.
>
> "But, apart from the mathematical triumph, a curious result emerges from the calculation. It is that *gravitation alone is incompetent to explain completely the observed motion of the moon.*" [The italics have been added.]
>
> "The moon for a generation past has been known never to have kept accurately to her time schedule ; but, that might have been because the problem of her movements had not been properly solved. Now that it has been solved, she still refuses to conform ; and astronomy is at a standstill for an explanation."

Various hypotheses have been put forward. One is that the force of gravitation is not constant. Another that the ether of space, the existence of which substance is entirely hypothetical, offers some frictional resistance. A third, which is the right one, is confirmed by Drayson as it is a suggestion that our standard of time is not fixed.

Regarding this last supposition it has been shown by Admiral Sir A. de Horsey that the error in standard time, which Mr. Stone

asserted had accumulated since the last adjustment in 1834, was exactly to a very small fraction of a second the same as resulted from an independent computation on Drayson's data.

Drayson in *On the Motion of the Fixed Stars*, devotes a whole chapter to the question of the moon's acceleration, and shows conclusively that it is the error in standard time which vitiates calculations. Astronomers, however, do not admit that there is an error.

The full explanation is somewhat lengthy and very technical. It must suffice to say that the initial mistake consists in taking a wrong centre for the curve traced by the pole of the heavens. With Drayson's centre it can be proved that there is *no* acceleration of the moon's mean motion. The demonstration of the solution of this riddle is alone sufficient warrant for the acceptance in full of Drayson's contribution to science.

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